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JOHN F. KELLY, EDITOR

CONTENTS

Vol. XI. JULY, 1934 No. VII

Utilization of Batch Furnaces for Heating—by T. B. Bechtel and M. H. Mawhinney, The Electric Furnace Company, Salem, Ohio 245

Use of Electric Furnaces for Box Annealing—by A. N. Otis, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y. 248

Temperature Distribution of Electric Furnaces Compared to Fuel Fired Furnaces—by Wirt S. Scott. Special Representative, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. 257

Discussion—Batch and Electric Furnaces—Discussion presented by H. G. Gibson, Wirt S. Scott, J. B. Brunot, A. N. Otis, F. E. Leahy, H. R. Belding, Lee Wilson, C. E. Gifford, Glenn Coley, G. S. Warren, M. H. Mawhinney, W. Anderson, T. W. Jenkins and H. Plott 262

Characteristics of Temperature Controls for Oil Fired Furnaces—by W. N. Horko, Electrical Engineer, Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa. 266

Tentative Program of A. I. & S. E. E. 30th Convention and Iron and Steel Exposition 269

Collective Bargaining—The Employee Representation Plan—by Tom M. Girdler, Chairman of the Board and President, Republic Steel Corporation 270

Special Lighting Feature at A. I. & S. E. E. Iron and Steel Exposition 273

Items of Interest 274

Iron and Steel Exposition Floor Plan 276

The Steel Industry at a Glance 278

Stabilization in the Steel Industry under the National Recovery Act—by Robert W. Wolcott, President, Lukens Steel Company, Coatesville, Pa. ..... II-III

Index to Advertisers IV

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Stabilization In The
The National

Today, conditions in the steel industry of America are stabilized to a degree that constructive minds in the business often dreamed about but never thought possible of attainment. What this stabilization means to the millions of people directly or indirectly concerned with the steel business is not generally appreciated, because few people realize fully the far-reaching influence of the disastrous marketing malpractices which prevailed in the steel industry over a period of many years prior to the adoption of the code of fair competition of the iron and steel industry under the National Industrial Recovery Act.

In past years, all industry complained of cut-throat competition. The steel business was no exception. Everybody, sincere and insincere, talked about it. Most people participated in it; many because they thought the immutable law of self-preservation forced them to do so. Others contributed their share to the havoc because they lacked the vision necessary to an appreciation of the ultimate chaos their actions would produce. No effort to correct conditions was ever successful for any lengthy period of time prior to NRA. Attempts were made, it is true, to correct unethical trade practices, but optimistic and constructive individuals soon ceased their efforts in the face of undercover treachery instead of the promised co-operation.

ROBERT W. WOLCOTT

Base prices for the steel industry's products were the focal points of cut-throat attack. Year after year, the unpleasant pastime proceeded until the point was reached at which the producer, on every sale of practically all the products he made, was giving away actual dollars from his company's cash. The commercial enterprise became an eleemosynary one, except that nobody ultimately benefited from the steel industry's eleemosynariness. Extras, the charges over base price which years of experience had proved necessary and equitable because of the increased production costs the work covered by them involved, were secretly conceded to the buyer, either for the sake of the much-revered volume or for the sake of obtaining the order. "We give you the extras without the extras charge" might well have been the motto disgracing the walls of many a sales department. The added expense required in meeting unusually stringent specifications of buyers was given little if any consideration in selling price; rejections of material were made on the basis of flaws detected by magnifying glasses and searchlights, yet no premium was added to the price of steel that had to be produced to pass such exacting inspections.

The base price was simply the base from which price-cutting started. Down, down it went, in the familiar ever-descending spiral. In an effort to acquire a major volume of the tonnage on a large order, a producer would slice the existing base price to a new low. Immediately, this lowered price, unofficial and unpublished as it might be, became the industry's standard for the product for all practical purposes. And hand in hand with each price cut went increased loss to the producer that forced him to make further retrenchments in labor costs and other items of production expense.

In good times and in bad times, such conditions were ever with the industry. Now that we look back on an old order, we wonder why this industry or any industry, comprising a group of about half a million people directly concerned with it and supporting about two and a half million others, would countenance continuation of such conditions for years. We wonder why this industry, or any industry exerting so widespread an influence on the nation's welfare, would ever permit itself to operate without mutually acceptable regulations that would be considered as vitally essential to the proper conduct of a small settlement of only a few hundred people in the most remote wilderness.

Since the inception of the code of fair competition of the iron and steel industry, the destructive and disastrous practices of the past have become only a bitter memory. The provision that members of the code must file their lowest prices with the code authority at least ten days before they are effective has brought the price situation out into the open and this provision is the most important single guarantee of fair competition in the industry; it is the backbone of the accomplishments that have been already effected, and of the future improvements that will come, in market conditions, wages, employment, and capital returns.

Today, we find the steel industry as a unit lending its efforts to rectification of past faults, inbued with a determination to build on a solid, constructive foundation for the future, abiding by its code's regulations and possessing a keen appreciation of its responsibility to its workers, customers, stockholders and to the general welfare of our country, for no industry as important and large as the steel in-

Steel Industry Under Recovery Act

By ROBERT W. WOLCOTT

President, Lukens Steel Co., Coatesville, Pa.

dustry can be conducted in such a demoralized way without injuring all allied industries and business in general.

The buyer or consumer of steel, prior to the inception of the code, could never be certain his purchase of steel was as cheaply consummated as was that of his competitor. The difference might be only a few cents, but in many instances it meant the difference between profit and loss. For example, in the automotive industry, a few cents' increase in the cost of the unit of purchase, multiplied by the number of the units involved, would mean dollars of difference in manufacturing cost and in turn mean the difference between profit and loss for the automobile manufacturer. With the new order in the steel industry under the code, the buyer knows that circumstances being like, the cost of his competitor's steel is identical with his own. The buyer knows today that the base price to him, the extras if any he must pay, are exactly the same to his competitor on similar material. The ultimate consumer of steel knows that his specifications cannot be dodged, for the code permits no concessions to the fabricator on items such as quality and gauge. Truly, the code has eliminated nightmares for both steel buyer and consumer alike.

Similarly, for labor, the correction of past malpractices has been a boon. When the industry was beset by demoralization of its price structure, individual management had no recourse but to endeavor to bring its costs to the figure that would permit it to balance income and expense and thus continue its corporate existence. In any study of costs, one of the items always looming largest was that of salary and wages. Naturally therefore, executive and laborer alike suffered financially because the industry lacked operative by-laws that would correct or eliminate cut-throat price competition. With each successive slash in base price, management was forced to make further retrenchment in costs to meet the lowered price it received for its products. Here again was the ever-descending spiral, probably most vicious of all in its national economic effect. Each wage cut, each lay-off, cut purchasing power of the industry's employees. Multiplied by the number of units throughout all industry that were also forced to slash wages and personnel, tremendous reduction was made in national purchasing power. Cut wages and salaries one month and ostensibly a saving of thousands of dollars was effected. But with all industry's buying lessened by lowered purchasing power, the next month's figures might show a loss entirely offsetting the apparent saving of the month before. The economy dog was simply turning around and biting his tail.

With the inception of the steel industry's code and the correction of destructive price-cutting practices of the past, quoted prices are nearer in line with costs, although from the summer of 1933 to the present time there has been only a relatively small advance in the average prices for the industry's products—less in fact than for general wholesale prices. The latter in February of this year had increased nearly 22 per cent while prices of finished steel had increased less than 6 per cent over the same period. Small as is the price increase for the steel industry's products, it has nevertheless enabled management to increase the return to labor and to add thousands of additional workers to the payrolls. Since June of last year before the code was in effect, the number of workers in the steel industry has increased 20 per cent, and the average earnings per hour for these workers has increased over 34 per cent. During the same period the average hours of work per week were reduced but 19 per cent.

As far as Lukens Steel Company is concerned, ours is a comparatively small corporate entity in the steel industry. Our ingot capacity is only about 600,000 tons of the industry's total of about 60,000,000 tons. Today in comparison with March of last year, before our industry's code went into effect, Lukens has on its payrolls over 64 per cent more employees. This equals our all time high in number of employees, which figure was reached only once before in our history.

Today, the average hourly earnings of all our employees (not skilled workers alone) is equal to the average hourly earnings in the year 1930 before any decreases were made. Today, the average hourly earnings of all our people are about 31 per cent higher than they were before the code went into effect.

Through periods of declining production levels, reduced forces and decreased wage levels, it was inevitable that inequalities in earnings and working hours at various occupations should creep in. With an upturn in company income through price stabilization and increased industrial activity and the attendant upturn in wage levels, close co-operation of labor and management was of paramount importance to a successful bridging of the readjustment period. The elected body of employee representatives cited existing wage and hour inequalities, inviting adjustment wage raises in preference to uniform percentage raises, and they solved this problem by means of a base wage analysis prepared by R. Conrad Cooper, Field Engineer of The Chas. E. Bedaux Co., of New York. This analysis, based on progressive and scientific consideration of such elements as skill, training, responsibility, working conditions, hazards, and other factors, proved satisfactory to both labor and management because it developed an equitable basis for readjustment. The uniformly fair and unbiased effort contributed to this development enabled successful bridging of the readjustment period and brought management and labor closer together for the common good of all concerned.

From the standpoint of our capital structure and invested capital, again the stabilizing effect of the steel industry's code has been of tremendous value. Increased prices for our products and greater volume of business have permitted us to meet bond interest. Likewise, improvement in our cash position has permitted us to make literally hundreds of vitally essential improvements in our plant and equipment, which has not only helped us to put more men at work but has aided vendors of our equipment and supplies to spread employment and increase mass purchasing power.

INDEX TO ADVERTISERS

A

The Alliance Machine Co. 296
Allis-Chalmers Manufacturing Company 301
American Air Filter Co., Inc. 282

B

G. H. Bales 299
The Bantam Ball Bearing Co. 304
Bussmann Mfg. Co. 277

C

Carnegie Steel Company 295
Crocker-Wheeler Electric Mfg. Co. 292
Cutler-Hammer, Inc. Cover 1

D

Darling Brothers, Ltd. 282

E

The Electric Controller & Mfg. Co. 287
The Electric Furnace Co. 280-281

G

General Electric Company 293-Cover 4

H

Hyatt Roller Bearing Company 286

I

I-T-E Circuit Breaker Company Cover 3

J

Jefferson Electric Company 285

L

Ladd Equipment Co. 299
Lewis Foundry & Machine Co. 289

M

Mackintosh-Hemphill 284
The Martindale Electric Co. 298
McGraw Electric Co. 277
McVoy Hausman Co. 299
The Morgan Engineering Company 303

N

National Carbon Company, Inc. 298
The New Departure Mfg. Co. 283
New York & New Jersey Lubricant Co. 297

O

The Ohio Carbon Company 302

P

Pennsylvania Transformer Co. 297
Poole Foundry & Machine Co. 299

R

Reliance Electric & Engineering Co. 294
Reitz Sales Co. 299
Rockbestos Products Corporation 302

S

SKF Industries, Inc. 279
Stimple & Ward Co., Inc. 300
Surface Combustion Corporation 288

T

The Thompson Electric Co. 300
The Timken Roller Bearing Company 291
The Tool Steel Gear & Pinion Co. 290

U

Union Carbide & Carbon Corporation 298

W

Westinghouse Elec. & Mfg. Co. Cover 2

Utilization of Batch Furnaces For Heating

By T. B. BECHTEL and M. H. MAWHINNEY
The Electric Furnace Company, Salem, Ohio

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

The purpose of this paper is to point out how the homely batch type furnace can be made to challenge the supremacy of the modern continuous furnace by proper arrangement of equipment. This involves not so much the design of such equipment as the proper utilization of batch furnaces for the solution of heating problems commonly met in the steel mills.

M. H. MAWHINNEY

T. B. BECHTEL

Thirty years ago industrial heating furnaces were almost entirely of the batch type, with the exception of large continuous furnaces for heavy billet heating, and were of extremely crude design. Accurate heat treating was unknown in the steel mills, as was the theory and practice of furnace design, as now known.

With the introduction of heat resisting alloys, continuous heat treating furnaces were built for automatic handling. Electric furnaces revolutionized temperature uniformity and control, and spurred the development of burners and control equipment for fuels, as well as refinements in furnace construction necessary to maintain atmospheres in the furnace. The automobile and kindred industries led in these developments, but with the advances in metallurgy, the steel companies became more involved, and have slowly reformed their traditional conceptions of heating furnace design and operation.

In spite of the amazing developments in automatic and continuous heating equipment, which are yet continuing to grow, there are certain products which defy all effort at satisfactory continuous handling in furnaces. These products include long tubes, miscellaneous bars in odd lots of size and analysis, car wheels, miscellaneous castings, etc. Many attempts have been made to handle such products continuously and the resulting monstrosities are almost entirely unsatisfactory for one of two principle reasons. Either (1) the product is handled satisfactorily but in such manner as to prevent the possibility of satisfactory heating, which is, after all, the purpose of the furnace, or (2) the cost of maintenance of the alloy conveying means is economically unsatisfactory.

These difficulties have led to the recent introduction of the principle of multiple batch type furnaces, in line with proper handling equipment for the solution of this problem. Briefly, this new principle comprises a series of similar single-end batch furnaces with their fronts in line and a fast handling means outside the furnaces which, in effect, ties the series of batch furnaces together to form a continuous producing unit.

There is a variety of possible arrangements, all alike in principle, and all incorporating the following principal advantages:

1—Simplicity of furnace construction with no moving parts in the heat.

2—Flexibility of capacity, since only the number of units required need be operated.

3—High economy at all rates of production since units in operation are always at maximum capacity.

4—All handling machinery available for repairs without interference to production.

EXAMPLES OF BATCH APPLICATION

Miscellaneous Tubes

The first application of this principle with which the writers are familiar is in a tube mill where nine batch furnaces of the car type are utilized for the continuous heat treatment of miscellaneous tubes. Figure 1 shows this installation.

The problem in this case involves the heat treatment of miscellaneous lots of tubing with a wide variation in length, diameter, required temperature,

FIG. 1

heating time, and cooling cycle. In addition the tubes must be kept as straight as possible during heat treatment.

Each of the nine furnaces are identical in design except in length, and the fronts of all furnaces are in line. The tubes in quantities varying from 2 to 14 tons, are loaded on the supporting racks of the car and are heated from below by gas burners firing between the piers and manifolded in groups to allow a turn-down of 15.0 to 1.0 for the range of temperature and production required. Exceedingly uniform temperature at all temperatures is obtained by this method of firing.

The doors are electrically operated and the cars are operated at 60 feet per minute by electrical car pullers, using direct current with dynamic braking, and electrically interlocked with the doors to prevent wrecks. The crane is built generally according to standard mill specifications, with a rigid vertical movement and electrical stops to protect the car top. The special U-shaped prongs on the crane are on the same centers as the supporting racks on the cars and are located between these racks. The contributions of the electrical engineer to this type of installation are the principal reasons for its success.

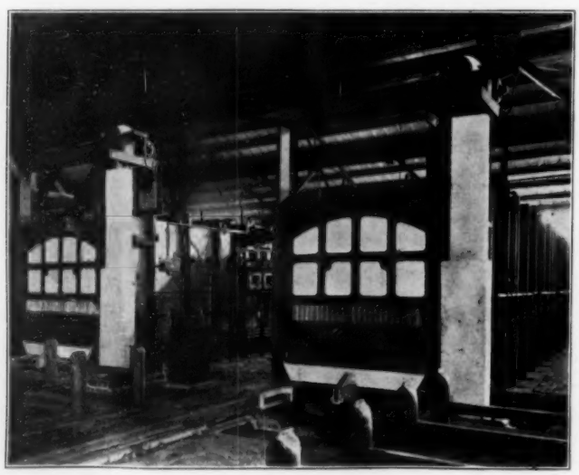

FIG. 2

The total time interval from the time the door is opened until the car has been unloaded, reloaded, charged, and the door again closed, is from 3 to 5 minutes, so that, in effect, the operation of this equipment is the same as if the nine furnaces were united into one giant furnace with a hearth area of 2835 square feet. The disadvantage of such a furnace in flexibility, economy, and maintenance, and the impossibility of operating one furnace at different temperatures and cycles are obvious.

Figure 2 shows a similar installation for similar work, comprising 3 furnaces and a crane, and installed in a plant of another steel company. Increase in production is taken care of by the addition of furnaces only, at comparatively small expense.

Alloy Bars and Shapes

Figure 3 shows an installation for the heat treatment of alloy bars of all kinds. Again, the material is in odd lots and requires a variety of temperatures and cycles. In some cases, the bars must also be quenched in oil or water.

In this case, the equipment includes one electric

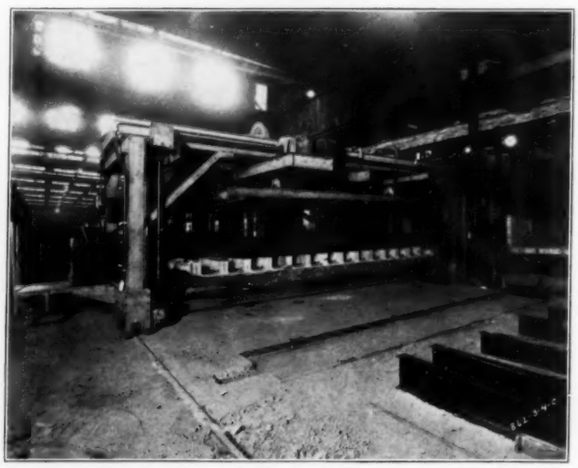

FIG. 3

car furnace for drawing, an electric car furnace for hardening, an oil fired car furnace for normalizing, quench tanks for oil and water, storage racks, and a fast gantry crane. On this crane, the special U-shaped prongs register between piers on the car and are moved in a vertical direction by cables and drums to permit lowering the charge rapidly into the quench tanks below floor level. All furnace doors and car pullers can be operated by push button control at the operating platform of the crane. Loading and cooling racks are in tiers to save floor space.

Figures 4 and 5 illustrate a single furnace and crane for heating channel sections used in the construction of bus chassis frames. In this case the sections heated are very light and a very light crane is used for handling the material from the furnace car into the quench tank. The furnace is underfired with gas burners firing between piers on the car, and the heating material is supported on alloy racks on the piers, as shown in Figure 4.

FIG. 4

Miscellaneous Parts

Another variation of the same principle is illustrated in Figures 6 and 7, showing equipment for heating miscellaneous steel castings of all sizes and shapes without the use of pans or containers and therefore with 100% net material heated.

The equipment includes two heating chambers of purely batch type in a common setting, loading and unloading racks, quench tank, and gantry crane with handling prongs.

In this case the hearth of the hardening and drawing chambers consists of longitudinal piers on close centers and with alloy caps to resist abrasion.

The prongs of the handling crane register with these piers, as shown in Figure 7, and rapidly handle the bulky castings in and out of the furnace and to and from the loading and unloading racks, as shown in Figure 6. The vertical travel of the crane also permits immersion of the charge in the quench tank below floor level. The capacity of the prongs in this case is 8000 pounds, and the depth of the furnace chambers is 8 ft. 0″. Doors are operated from the crane pulpit.

FIG. 5

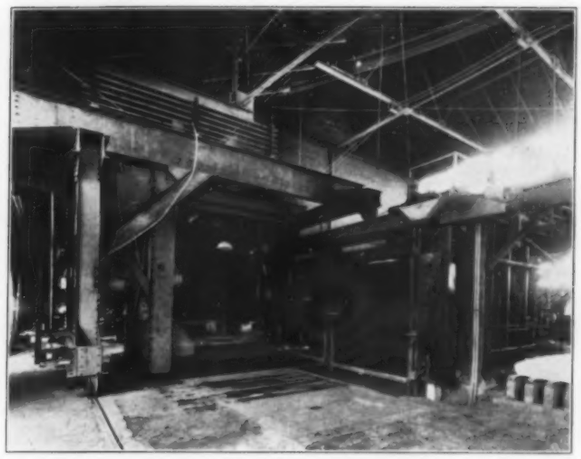

FIG. 6

The handling of material is again extremely rapid, and the amount of labor required for handling is amazingly low for this awkward and bulky material. The maintenance is practically nothing. This same arrangement may be successfully applied for a variety of products difficult to handle in continuous furnaces.

Wire Annealing

Another variation of this application is a series of pit type batch furnaces wherein wire is charged on alloy spindles by means of a crane. The spindles, holding as much as 3 tons of coiled wire or wire rod, are handled rapidly and easily in and out of the pit furnaces and the preheating and cooling pits located adjacent to the furnaces. The labor of handling is a minimum, and flexibility and economy are excellent at all rates of production.

In conclusion, it is hoped that the applications of batch furnaces as described will be of interest to combustion and electrical engineers of the steel mills, who are constantly confronted with the heating and handling of awkward and unwieldy products.

FIG. 7

Use of Electric Furnaces for Box Annealing

By A. N. OTIS
Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

In presenting the subject of electric furnaces for box annealing, data will be taken principally from furnaces for annealing silicon sheets used for electrical machinery, and from bell type furnaces, used for annealing coiled strip, since a number of installations of both these types of furnaces have been made, and good operating data is available thereon. Certain theories will be developed from this data, which it is hoped will stimulate further interest and study of the subject.

A. N. OTIS

The application of electric furnaces for large scale annealing operations in steel mills, such as for ordinary sheets or coils of wide strip, is still ahead of us, but the information secured from furnaces used for other purposes shows that they have the proper characteristics for annealing these standard sheets and wide coils.

A number of test runs have been made to secure fundamental information, and while this is by no means complete enough has been obtained to show the advantages of these furnaces, from the standpoint of speed of heating, uniformity of temperature distribution obtainable throughout the loads with the resulting uniformity of anneal, as well as the ability to accurately control the cooling rates and to employ protective atmospheres to prevent oxidation. It is desired to offer this data, and some conclusions therefrom, for consideration.

The problem of annealing silicon sheets presents unusual difficulties, first, because of the high temperatures required; the necessity for flatness of the sheets in order that when made into punchings, and stacked into the cores of large transformers or generators, that it will be possible to get the required amount of steel into the space provided; and further, the presence of absorbed gases or scale on the sheets, or mechanical stresses introduced by deformation, increases the magnetic losses.

The problem therefore is one of annealing these sheets without oxidation, without deformation, and without the absorption of gases which will be detrimental to the magnetic qualities. This work must be done at high temperatures, and it is well known that difficulties from warping or distortion increase rapidly with temperature.

Electric furnaces are being used to an increasing extent for this purpose, and it is entirely logical that they should first be employed for the most difficult problem at hand.

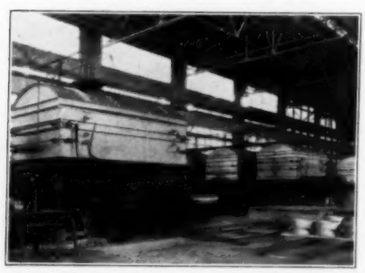

FIG. 1—Installation of elevator-type electric furnaces for annealing silicon steel strip punchings.

FIG. 2—Recent installation of rectangular bell furnaces.

The high temperatures required, which present a serious maintenance problem with fuel-fired furnaces, does not exist with electric furnaces, since protective atmosphere can readily be employed, and no covers or retorts are necessary. It is perhaps significant that practically every manufacturer of electrical sheets in the United States, and some abroad, has installed one or more furnaces for annealing this material, or has requested proposals and information in regard thereto.

Figure 1 shows an installation of eight (8) elevator-type furnaces installed at Pittsfield Works of General Electric Company for annealing punchings and strip for transformer cores. Three (3) similar furnaces are installed in an adjacent building and a number of others in various plants of the company. These furnaces were installed some years ago, and progress has been made not only in the design of

the furnaces themselves, but in the application of cooling arrangements, which are noteworthy.

Figure 2 shows a modern installation of rectangular bell-type furnaces for this purpose.

Figure 3 shows a modern arrangement of rectangular bell furnace in outline, indicating also the arrangement of a forced cooling system to extract heat from the load.

An atmosphere of hydrogen or hydrogen mixed with nitrogen is usually employed, being introduced directly into the heating chamber and in contact with the sheets. In addition to protecting sheets from oxidation, hydrogen annealing has generally been found to be beneficial in reducing magnetic losses, and some manufacturers of electrical machinery have annealed punchings and strips for transformer cores in hydrogen for many years.

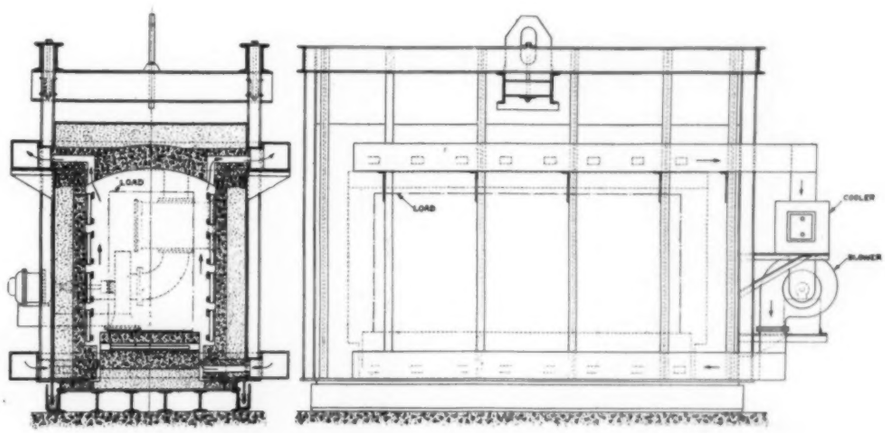

FIG. 3—Outline of rectangular bell furnace with cooling equipment.

The forced cooling system outlined was developed and used primarily for cooling loads of segment punchings at established rates, which rates had been found by experiment to produce the desired flatness.

The cooling system consists of a tubular finned surface cooler, water flowing through the tubes and the gas to be cooled being drawn between them, by means of a blower, which forces the cooled gas back into the heating chamber, thus maintaining a continuous circulation. The speed of cooling may be adjusted by regulating the speed of the motor, or the position of valves in the discharge side of the blower, so that any cooling rate desired within the capacity of the equipment may be maintained. The construction of the cooler is illustrated by Figure 4.

It will be noted in Figure 3, that the blower withdraws gas through lateral ducts spaced along each side of the arch, and delivers the cooled gas to similar ducts through the walls at the bottom. The cooled gas impinges on the brickwork of the base and flows upward along the edges of the sheets, to the suction ducts at the top. The arrangement is therefore such that the streams of cooled gas do not impinge directly upon the stack of sheets, which would tend to overcool them locally, and be likely to produce local strains and result in deformation.

The question of the proper method of cooling a stack of sheets to secure flatness has been the subject of exhaustive studies, but so far as the writer knows, the principles have not yet been fully established by tests. These studies however point to certain methods which give promise of a solution.

For example, it is debated whether the cooled gas should be introduced into the bottom of the furnace or into the top. In accordance with the latter theory, it is contended that a stack of sheets would cool naturally from the top, the sheets contracting in dimension, which contraction would gradually extend to the bottom, and thus cool all of them, so that the contraction would not be excessive in any portion of the stack. If the bottom sheets cool and

FIG. 4—Type of cooler employed with cooling system for electric furnaces.

contract first, it is considered that stresses may be introduced which will ultimately deform them, and cause deformation of those above. The problem then is the uniform cooling of the entire stack, at such a rate, and to such a final temperature that strains will not be set up in any part of the cycle that will later result in deformation.

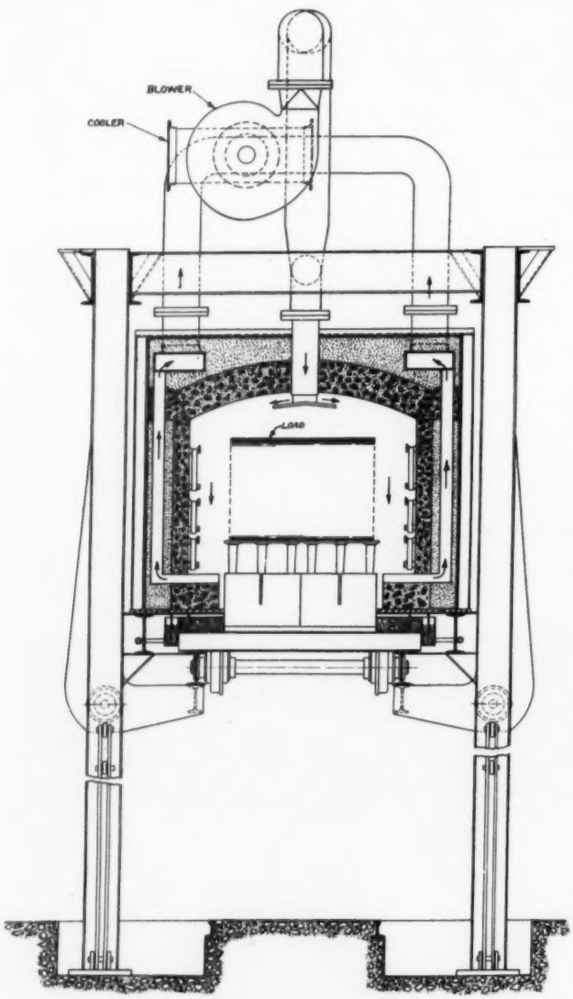

FIG. 5—Outline of elevator-type furnace showing alternative arrangement of gas flow.

Figure 5 shows an outline and the circulating system of an elevator-type furnace arranged to introduce the cooled gas into the top, in accordance with this latter method, the streams flowing downward along the edges of the stack. Figure 6 shows a load of sheets annealed in a furnace constructed in this manner.

This furnace is also provided with a different type of supporting structure for the load, consisting of hollow columns of cast heat resisting alloy, and sectional hearth plates also of cast heat resisting alloy, upon which the load rests directly.

This type of hearth construction permits some expansion and contraction of the bottom sheets in both directions and is probably beneficial in securing flatness.

The column or post construction is clearly indicated, also the joints or sections between the hearth plates. It will be agreed that these sheets present a high degree of flatness, but it is not known, at the present state of the tests, to what extent the flatness is due to the direction of gas circulation, the hearth construction, or the cooling rate.

It has also been proposed to reverse the direction of gas flow periodically, that is put gas into the top for 15 to 30 minutes, then into the bottom for an equal length of time.

The amount of work involved in the solution of this problem will be apparent, when it is considered that the experiments must be conducted in large furnaces, and the expense of changes is considerable.

It is believed that a solution will eventually be found in the proper correlation of; (1) direction of gas flow, (2) method of supporting the load, (3) cooling rate as related to different portions of the cooling cycle, and (4) the final temperature to which the sheets must be cooled in the moving gas. Further comments on this latter point will be made later in connection with the results secured with punchings.

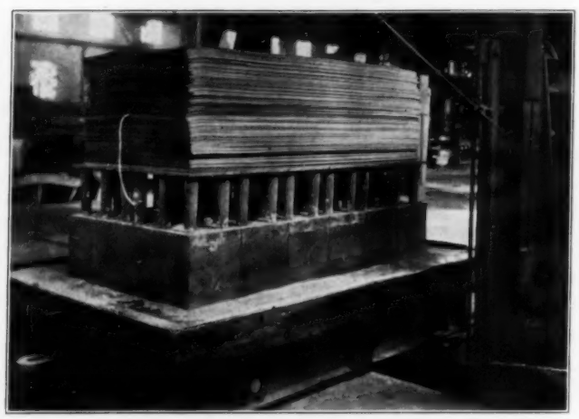

FIG. 6—Load of sheets annealed in furnace constructed as per Fig. 5.

In regard to the cooling rates obtainable, and the temperature distribution, Fig. 7 gives test data showing heating and cooling curves of loads of sheets annealed in an electric furnace equipped with a forced cooling system. The lower figure represents a load of silicon sheets. These sheets were of the usual gauge, .014" thick, thermocouples being placed at the middle point of the load, at top, bottom, center and at the edge of the stack. In this particular load cooling was controlled at the rate of 10 deg. C. (18 deg. F.) per hour for the first 30 hours and then accelerated to 15 deg. C. (27 deg. F.) per hour.

An interesting feature of this data is that there is no cool bottom. The bottom, top, center and edge rise in temperature at approximately the same rate and cool at the same rate, although of course the edge is hottest and the center coolest on the heating part of the curve and the conditions are reversed for the cooling portion.

This load was elevated above the floor of the furnace about as shown in Fig. 6, to permit radiant heat to enter the space between the load and the furnace bottom. It will be noted that at the end of

13 hours, when the furnace temperature is about 675 deg. C. (1247 deg. F.) that the bottom temperature increases its rate decidedly. This is due to the effect of radiant heat which becomes pronounced at this temperature, heat entering the space below the load, by direct radiation, from the units on the side walls of the furnace.

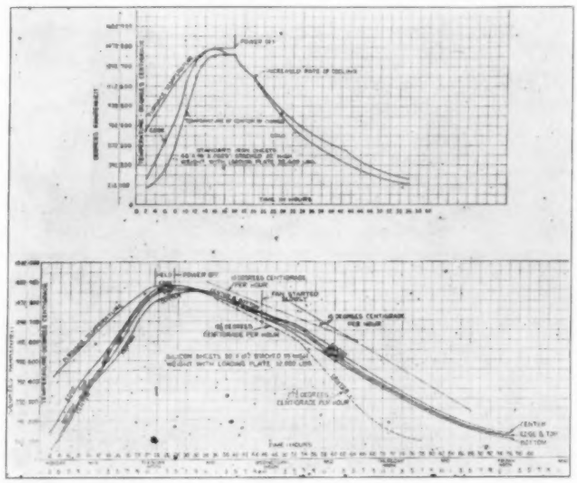

FIG. 7—Heating and cooling curves of standard iron and silicon steel sheets, in electric furnace with forced cooling system.

Heat is absorbed by a stack of sheets largely through the edges, particularly with high stacks. Due to the laminated structure, the joints of which offer resistance to heat flow, comparatively little heat is absorbed through top or bottom. Thick sheets should, therefore, absorb heat at a higher rate than thin sheets of the same width, and sheets of low resistance material should absorb heat at a higher rate than sheets of higher resistance material.

The electrical resistance of high silicon sheets (which is also an index of the resistance to heat flow), is approximately 2½ times the resistance of ordinary steel sheets. The rate of heat absorption for the latter, under the same conditions, should therefore be much higher.

While opportunity has not been presented to make a direct comparison on sheets of the same size, comparison of the upper and lower sets of curves in Fig. 7 will illustrate the point.

The upper curves show heating and cooling rates of a load of wide sheets of standard iron, .0625" thick, of approximately the same total weight as for the load shown in the lower curves. Both loads were heated in the same furnace.

It will be noted that the heating curve in the upper figure is much steeper—80 deg. C. (144 deg. F.) per hour, while in the lower figure, with narrower but thinner sheets of silicon steel, the maximum rate is 33 deg. C. (60 deg. F.) per hour.

Conversely, sheets of standard iron will give up heat more readily.

The upper curve illustrates more nearly the conditions which would exist in annealing ordinary steel sheets, except that the temperature used, for magnetic purposes, is somewhat higher than would be required if the sheets are to be used for other purposes. It will be noted that even though these sheets heat at an exceedingly rapid rate, the difference between edge and center temperatures is not excessive and, for this load, cooling at a higher rate was employed, the total cycle being 56 hours to 125 deg. C. (257 deg. F.) compared with 96 hours for the load of thin silicon sheets shown in the lower curves.

These curves also illustrate the flexibility of the cooling system, and the cooling rates which are practicable to secure if the cooling system is utilized at or near its full capacity. The dotted curve in the lower figure represents still another load of thin silicon sheets, which were cooled at 12½ deg C. (22½ deg. F.) per hour during the early part of the cycle, the rate being then increased to 27½ deg C. (49½ deg. F.) per hour.

These curves are presented primarily to show the heating rates that may be expected in furnaces of this type, the uniformity of temperature procurable from top to bottom, and the flexibility of the cooling system, as regards the rate at which heat may be extracted.

By way of comparison, the curves shown in Fig. 8 were taken from loads of sheets annealed in conventional type fuel-fired furnaces consisting of a heavy base and cover. The upper figure is reported not to yield flat sheets, the cycle as shown in the lower figure being adopted for the purpose of securing flatness. It will be noted that the cycle is much longer, and particularly that the cooling rate is much lower, being approximately 7 deg. F. per hour, whereas a rate of 20 deg. F. per hour was employed in the cycle shown in the upper figure. The overheating of the top of the stacks is also apparent in both of the curves, which of course is generally encountered in furnaces of this type. The relation between furnace temperature and temperature of the charge as

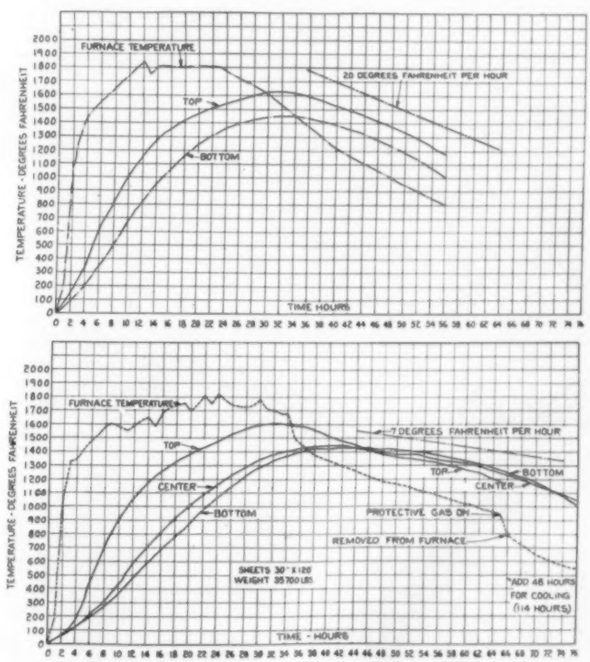

FIG. 8—Heating and cooling curves of loads of sheets in conventional fuel heated furnaces.

compared to a similar load in the electric furnace, Fig. 7, should also be noted.

With further reference to flatness, the three views, Fig. 9, of the same load of steel will be of interest. These views are of a load of transformer strip punch-

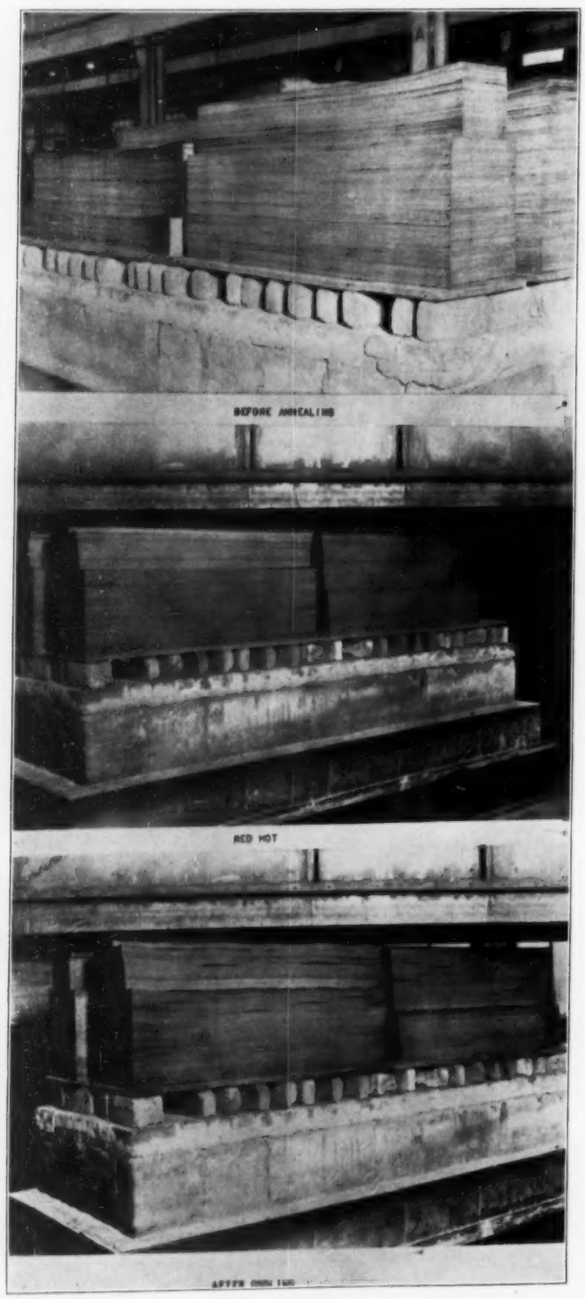

FIG. 9—Load of strip punchings before annealing, red hot, and after cooling in a steel plate hood.

ings, the upper view showing the load before annealing, the second photograph being taken when the sheets were removed from the furnace and while red hot, and the third after cooling in a steel plate cooling hood. The cooling of course was quite rapid.

It will be noted that while red hot, the strips are absolutely flat, and if they could be cooled in this condition, the desired result would be attained. The "eyes" produced in the stacks while cooling represent stresses built up either by too rapid cooling or by local cooling.

These photographs were taken some years ago, in the course of development work on this problem, and carry an important message as to what goes on inside an annealing box.

Fig. 10 shows a load of large generator punchings annealed in a furnace with forced cooling system under controlled rates. The flatness of these punchings is all that could be desired. The total cycle is 55 hours, and is practically the same as the upper curve of Fig. 7; so close in fact, that it is not repeated here.

In addition to flatness, an important requirement for this operation is that the teeth shall remain straight, i.e., shall not be distorted out of alignment by warping during the anneal.

The theory of cooling such loads points to the desirability of cooling all surfaces of the stacks at a uniform rate, thus eliminating local cool or hot areas, which might result from the local currents that exist in natural cooling, (natural cooling takes place largely by convection currents) and thus build up local stresses sufficient to cause deformation.

If the velocity and distribution of the gas is such as to extract heat at a uniform rate over all the surfaces, local currents, and deformation which might result from them, should not occur.

This is the principle employed in tempering ovens and similar apparatus, where fans circulate the air or atmosphere of the chamber to produce uniformity of heating. For example, thermocouples distributed through a batch of bolts the size of a barrel, will show exceedingly close temperatures throughout the batch.

Stacks of punchings or stacks of sheets, while of larger size, should obey the same laws, and the problem should therefore be one of extracting heat uniformly, at such a rate, and to such a final temperature, that deformation will not result. Since heat in such a stack is absorbed largely through the edges, it will also be dissipated through the edges, therefore the currents of cooling gas should pass these areas.

Cooling should continue to a low temperature, experience with loads of punchings, as in Fig. 10, having shown that distortion is likely to take place unless the stacks are cooled to a temperature of approximately 125 deg. C. (257 deg. F.). Apparently local convection currents along the edges, induced by the remaining heat, when removed from the furnace at a higher temperature than this, will tend to cool locally at different rates, sufficient to produce distortion.

The required conditions as above set forth, can be obtained in an electric furnace with forced cooling system as outlined, and while time and opportunity have not yet been available to determine the effect of each individual factor, the major conclusions appear to be well founded, and are worthy of consideration by those confronted with annealing problems.

The energy required for annealing silicon steel, by the methods outlined, is approximately 240 kwh. per net ton, and will vary of course with the annealing temperature and time cycles employed. A

cycle of approximately 100 hours is required, and this is quite independent of the size of load, smaller loads or larger loads requiring approximately the same time.

In regard to the application of furnaces of this type for annealing standard steel sheets, reference to the present practice may be made as a comparison. The average cycle in present practice consists of

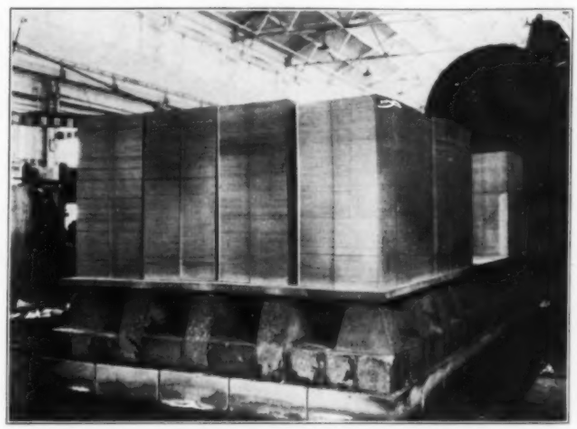

FIG. 10—Load of punchings for large generator, annealed in furnace with forced cooling system.

bringing the furnace up to temperature in 12 hours and holding it at temperature 12 hours, after which the load may be withdrawn from the furnace at full temperature and allowed to cool in the room for 24 hours under a cover, and 12 hours without a cover, a total of 60 hours before the sheets are unloaded.

If flatness is desired, the load is allowed to remain in the furnace an additional 24 hours for cooling, or 48 hours in the furnace, then remove and cool 24 hours under the cover and 12 hours without the cover, a total of 84 hours. The time will generally be longer for wider sheets; 48" sheets, for example, remaining in the furnace for a total of 60 hours and 36 hours cooling outside the furnace, a total of 96 hours.

By reference to the upper curve of Fig. 7, showing a heating cycle for 48" wide sheets, .0625" thick, it will be noted that the center of the stack reaches 700 deg. C. (1292 deg. F.), the usual annealing temperature, in about 13 hours, and cooling could undoubtedly start in 20 hours. If cooled at the rate of 10 deg. C. (18 deg. F.), a total cycle of 76 hours would be required for the anneal to 100 deg. C. (212 deg. F.).

It may be found practicable in operation, to transfer the sheets from the furnace to an insulated cooling hood, also supplied with gas, at the end of 48 hours, which would release the furnace for another load, the temperature of the transfer being for example 350 deg. C. (662 deg. F.).

Such transfer tests have been made, which did not result in discoloration of bright sheets, but they were not full size sheets, and the observations regarding flatness would not apply.

It may be practicable to make the transfer at higher temperatures than indicated, but the conditions to be met as regards oxidation of edges, flatness, etc., would be governing considerations to such a procedure, and of course would vary with the kind of material of which a specific load is composed.

Therefore, while the application of furnaces of this type for annealing standard sheets has not been entirely worked out, there is little doubt as to their suitability for the purpose, the only questions remaining being those of economy, and the determination of methods and cycles to produce the required physical properties and finish for sheets of various grades.

There is no question of the superiority of temperature distribution obtainable, since, as shown in the curves, the top, bottom and center temperatures are close together throughout the cycle. It should also be pointed out that the heat distribution is fixed and invariable, and is not subject to irregularities in firing or other manual errors.

The use of such furnaces will unquestionably give consistently uniform physical properties to the sheets so far as the anneal is concerned.

The energy required for annealing standard steel sheets is estimated at 150 kwh. per net ton, and a time cycle of 72 hours is estimated from present data. These will vary somewhat with the temperatures required, and the nature of the work to be done.

Theoretically, there is no limit to the height of stack that can be annealed in an electric furnace. The heating units would be divided into relatively short sections or zones in the height, each section

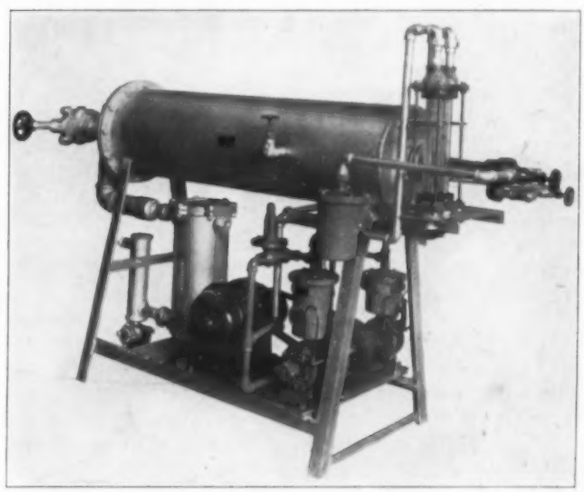

FIG. 11—Combustion type atmosphere controller, using hydrocarbon gas, for producing atmosphere for annealing furnaces.

supplying the necessary heat to the steel in its area. The heating time would also be quite independent of the height of stack, since the heat is supplied locally, but of course more power would have to be applied to anneal in a given time interval, and the cooling equipment also made larger.

Sticking of the sheets would probably be a limiting feature to the height of stack, and possibly also less flatness would be secured. However, substantial savings in cost of equipment per ton of output, also in floor space, and heat requirements will result from annealing in higher stacks, and this feature should be given due consideration.

For annealing ordinary steel sheets an atmosphere

of hydrogen is not required as in the case of silicon sheets. Since the only purpose of the atmosphere is to protect the sheets from oxidation, atmosphere from a combustion type producer, using coke-oven gas or natural gas could be employed. This apparatus is shown in Fig. 11.

It consists of a combustion chamber and other accessories, and is arranged to burn hydrocarbon gas with a deficiency of air, usually about one-half the amount required for complete combustion. The water-vapor product of combustion is condensed, and the resulting product gas consists of approximately 6% each of Hydrogen, CO, and Co_2, with balance nitrogen from the air. The combustion ratio is usually set at 3 to 1 for coke-oven gas, and 6 to 1 for natural gas, to yield a product gas of analysis stated.

There is an increase in volume of 3 to 1 for coke-oven gas, and 6 to 1 for natural gas, so that the cost of the product gas may be obtained by dividing the cost of raw gas by 3 and 6 respectively.

This apparatus is exceedingly simple in construction and operation, and the product gas has been found to be entirely suitable for bright annealing operations on steel, copper, nickel silver and other metals. Also it is low in cost, as indicated, and low in inflammable elements, so that it is very safe—a desirable property for steel mill applications. A considerable number of these equipments are in use, and are giving highly satisfactory results. They are built in number of sizes, from 200 cu. ft. output per hour, to 4000 cu. ft. per hour, and multiple units of the latter size can be assembled together to produce any quantity of gas desired.

The problem of annealing sheets which have been cut from strip rolled on continuous mills, presents certain difficulties due to the brightness or planeness of the sheet surfaces. It has been found that when sheets of this kind are heated in a high stack, the weight and the planeness of the surfaces cause the sheets to stick or weld together by crystal growth between them, if temperatures above 1050 deg. F. are used.

For certain deep-drawing qualities, it is desirable to use higher annealing temperatures, on the order of 1300 deg. F., which causes the sheets to stick. The alternative is to anneal the strip in the coiled form, then cut to length and give a flattening pass.

Coils make a bulky load, of less than one-half the weight of a load of sheets of equivalent volume, and for heavier gauges, it is preferred to anneal flat in addition to the better economies which result from the heavier loads.

For this operation, and also for annealing cut lengths of flat cold rolled strip, the use of a continuous furnace, passing the sheets through in light packs, has been suggested. Pack furnaces are now employed to some extent for normalizing tin plate, and if an electric furnace with suitable atmosphere to prevent oxidation and discoloration of the sheets be employed, there is every reason to expect superior results. The operation would approach a box anneal, but be of shorter time duration. It would be a compromise between a box anneal and a single sheet anneal.

Sheets would be put through in packs of about 1" thick, the time in the furnace being approximately 2 hours, the sheets passing from the heating chamber through a cooling chamber also provided with the protecting gas, so the packs of sheets could be annealed in comparatively few hours instead of several days as now employed. The weight of the pack and the time at temperature would not be sufficient to cause crystal growth and sticking, and the sheets could be annealed bright. It would be necessary to

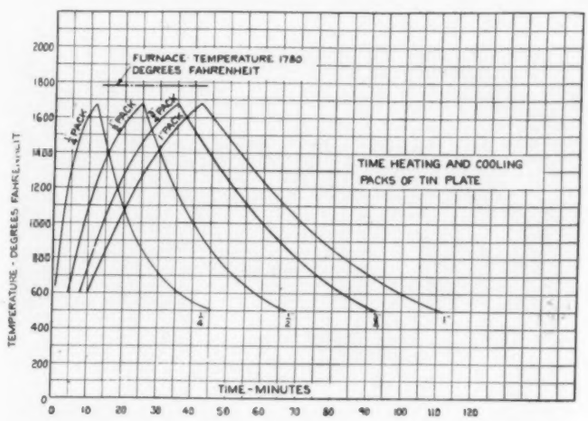

FIG. 12—Heating and cooling rates of packs of tin plate in a continuous furnace.

determine the permissible height of stack, and the time cycle to secure the desired physical properties, and operating characteristics as regards flatness.

In this connection, Fig. 12 shows the heating and cooling time for packs of tin plate ¼" thick, ½", ¾" and 1" thick. The times were measured to a normalizing temperature of 1680 deg. F. in a furnace, the temperature of which was controlled at 1780 deg. F.

While this data does not apply directly to annealing bright steel sheets in packs, it may supply some information of interest in this connection.

By the use of such a furnace, the time interval between rolling and shipment could be very greatly reduced, in many cases permitting shipment the same day that the material is rolled.

The rectangular furnaces previously described for sheets could be used for annealing wide strip in coils, although greater speed of heating and better uniformity can undoubtedly be secured in individual cylindrical furnaces for each stack of coils, the reasons for which will be pointed out later.

Coils of strip 36" wide, 24" i.d., 48" o.d., would weigh approximately 7000 lbs. and two such coils could be annealed per load in a relatively small cylindrical furnace, making a load of some 14,000 lbs., or 7 tons.

Fig. 13 shows a typical installation of bell type furnaces for annealing narrow coiled strip, the coils being 16" i.d., 36" o.d., and stacked 4½ ft. high, weight approximately 11,000 lbs. This particular group of furnaces is used largely for annealing high-carbon strip, .70 to .80 carbon, but the general type of construction woud apply to furnaces for annealing wide coiled strip, except of course the size would be increased.

The furnaces are provided with a central heater that extends downward into the stack of coils, which increases the heating rate and greatly improves the

uniformity of temperature distribution obtainable in a given time.

Fig. 14, lower curve, shows the heating time and temperature distribution, in a stack of coils annealed in one of the furnaces shown in the photograph.

FIG. 13—Typical installation of cylindrical bell-type electric furnaces for annealing coiled steel strip.

Thermocouples were placed at the top, middle and bottom, both on the inside and outside turns, and one at the center of the middle coil. This of course, is the coolest spot in the load, since heat to reach these inmost layers must pass through the laminated structure of the load. These laminations tend to retard heat flow, as has already been pointed out, and the time of heating of such a load, therefore, is subject to the laws of heat transmission and the temperature gradient carried, there being little that the designer can do except to properly apply the heat for good distribution and the minimum time cycle which the physical arrangement of the load permits.

It will be noted that fairly close temperature equalization obtains throughout the load in 12 to 13 hours except for #4, which is at the very center, and that 18 hours is required for complete equalization of temperature. This is for high-carbon steel, in which the temperature distribution required is very exacting. The tests have shown equalization within 15 deg. F. total range.

Low-carbon steel is annealed at a lower temperature and, furthermore, large diameter coils, such as described above, provide more space inside for a central heat of large capacity, and also more internal surface area for the absorption of heat, permitting more equal application of heat to inside and the outside of the stack. Under these more favorable conditions of heating, it is estimated that a 7-ton load would reach temperature in 9 to 10 hours with sufficient uniformity of temperature distribution to give the desired physical properties. For more accurate equalization of temperature, additional time might be required.

Such a furnace would therefore have a capacity to anneal approximately 18½ net tons per day of 24 hours. The equipment would consist of one heating chamber and 4 or 5 bases, to allow cooling time between heats.

By way of comparison, the upper curve of Fig. 14 shows data from a conventional fuel-fired furnace for annealing wide coiled strip, 8 stacks of coils being loaded per charge. The temperatures are indicated for the top and bottom of the coils at the end of the furnace and at the middle of the furnace. No temperatures were taken of the inside, outside and center turns of the coils, as was done for the electric furnace shown in the lower set of curves.

In this particular run, the burners were shut off at 16½ hours. The curves indicate that the top of the coils reached temperature in approximately 3 hours after starting, and remained at full temperature or above throughout the remainder of the run, waiting for the bottoms to come up. The bottoms never did reach annealing temperature, but the curves have been extended to indicate the probable conditions which would exist if run for 24 hours.

It is difficult to see how uniform physical properties from one side of the strip to the other can be secured when the strip is annealed under these conditions.

It will be further noted that with this load of 8 coils containing approximately 31,000 lbs. of strip, the output would be approximately 15 net tons per 24 hours, whereas the bell type furnace described above would have a capacity of approximately 18½ net tons. It would occupy much less floor space and, with auxiliary equipment, would probably have less first cost, would anneal the strip bright, and with decidedly better uniformity.

In this connection, it may be pointed out that the ideal way to anneal such material would be in

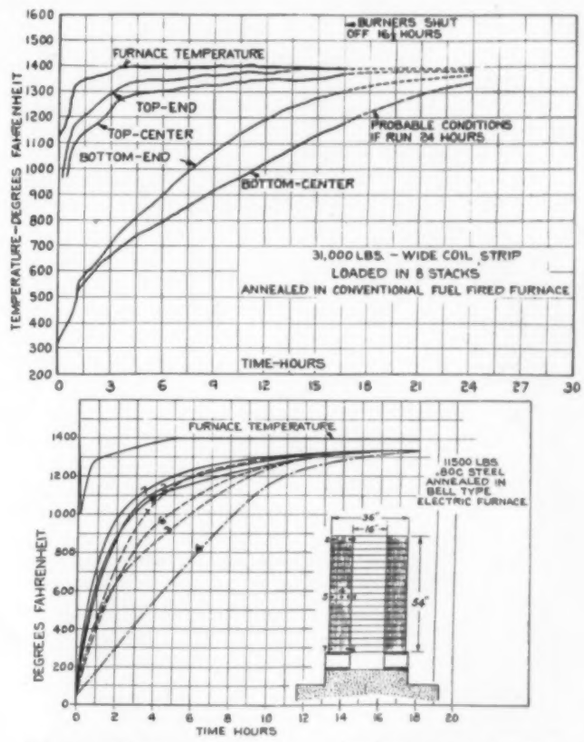

FIG. 14—Curves of temperature distribution and heating time of loads of coiled strip in fuel heated and electric furnaces.

the form of a thin cylinder, constituting the thickness of one layer or turn. Such a load would heat in a very short time, with absolute uniformity, but of course it would be impracticable for economic reasons to operate a furnace in this manner.

An operative furnace, therefore, must be a com-

promise between the ideal furnace annealing a single thin cylinder, and one to take a size of load which will give reasonable productive capacity and economy.

The thickness of the coils will therefore be determined by how far we may go in thickness, and yet secure the desired uniformity and physical properties of the strip, together with reasonable economy in operation. It is believed that a 10" or 12" thickness of coil presents no serious difficulties in obtaining uniformity of temperature distribution and physical properties, provided the heat is applied in a proper manner to obtain the desired results. The time required of course will be governed by the thickness of coils.

In this connection a closer study of the lower curves in Fig. 14 will be of interest. It will be noted that Nos. 2, 5 and 7, the outside temperatures, are close together all the way, indicating proper heat distribution from top to bottom. No. 1, at the top inside, follows them closely, and it probably gets some heat from the outside top unit.

Nos. 3 and 6 however are slow, indicating that more central heat would be desirable. This would also increase the rate of No. 4.

The space limitations with coils of this size however, prevent the use of a larger central heater, and the obvious thing to do would be to decrease the capacity of the outside heaters, so that they will come up at the same rate as the inside, indicated by Nos. 3 and 6.

From the foregoing, it will be apparent that with coils of larger diameter, for example, 24"x48", which would provide more space for a central heater of larger capacity, and more internal surface area for absorption of heat, the heating time can be proportionately shortened, and greater uniformity secured. This principle extended, returns to the theory of the thin cylinder.

A study of this portion of the subject will lead inevitably to the conclusion that box annealing of coils by the usual method, is wrong in theory, and that heat should be applied to the inside of the stack of coils, if uniformity of heating is to be attained in a reasonably short time.

Some manufacturers employ the box method, however, and some even double-wind the coils, making them very thick, and anneal in heavy loads, 8 stacks per load for example, requiring a very long heating time. This practice is directly contrary to the theory as above set forth, and it would be interesting to examine records of temperature distribution throughout the stacks of such a load.

It would probably be found that the tops of the coils, and the outer turns, particularly the portions toward the furnace walls, reach annealing temperature and remain there some 25 hours, while the inner mid-turns and the bottoms are coming up. Considerable differences in temperature between the middle and end stacks of the load will undoubtedly be found also.

When the physical arrangement of such loads is considered in conjunction with the well established laws of heat transmission, it is believed that the correctness of single stack method will be obvious.

Care has been taken to outline these characteristics with sufficient clearness to enable those familiar with this kind of equipment and the results expected from it, to reach their own conclusions.

The energy required for annealing coiled steel strip in electric bell-type furnaces, will vary with the requirements. Records from those illustrated by Fig. 13 show that for low-carbon steel, average annealing temperature 1200 deg. F., it requires 131 kwh. per net ton, averaged over a period of months.

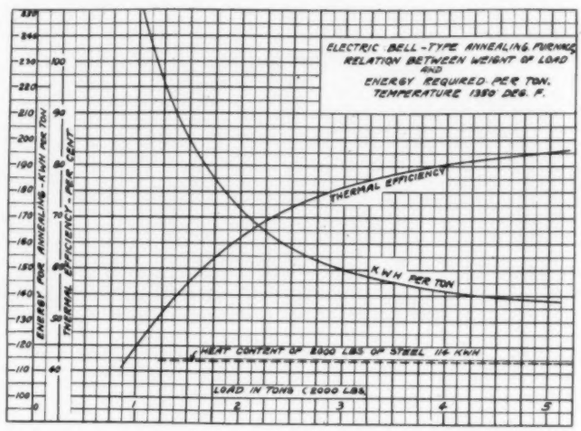
ELECTRIC BELL-TYPE ANNEALING FURNACE
RELATION BETWEEN WEIGHT OF LOAD AND
ENERGY REQUIRED PER TON.
TEMPERATURE 1350 DEG. F.
THERMAL EFFICIENCY
KWH PER TON
HEAT CONTENT OF 2000 LBS OF STEEL 116 KWH
LOAD IN TONS (2000 LBS.)
ENERGY FOR ANNEALING - KWH PER TON
THERMAL EFFICIENCY - PER CENT

FIG. 15—Characteristic relation between weight of load and energy required per ton, for annealing coiled strip in bell-type electric furnaces.

For high-carbon steel, annealing temperature 1320 deg. F., and for which considerable holding time at temperature and slow cooling in furnace is required, 188 kwh. per net ton was averaged over the months. The loads average 11,000 lbs.

Fig. 15 shows the characteristic relation between weight of load and energy required per ton for annealing in bell-type furnaces. The thermal efficiency is also indicated. The values will vary with the size of furnace and the annealing temperature. Those given by the curves should be considered as typical only.

It will be noted that the curves flatten as the weight of load increases, and that good economies, in the size furnace referred to, are secured with loads of 3 to 3½ net tons and above. With light loadings, the heat required for the base and the retort, and for supplying the furnace losses, is larger in proportion to the heat requirements of the steel, thus adversely affecting the economy.

For coils 24"x48" diameter, larger retorts of heavier gauge metal would be required, and the bases would be heavier, since the weight increases as the square of the diameter.

These factors, however, will not increase at a higher rate than the weight of load, if the thickness of coils and loading height are properly selected. The size of furnace, therefore, does not adversely affect the economy, although with larger furnaces it is more important that light loads be avoided.

For 7-ton loads of such strip, annealed at 1300 deg. F., the usual temperature for this material, it is estimated that 9 hours time and 150 kwh. per net ton would be required, this estimate being based on continuous operation of the furnace. It should be noted that the weight given would be for loosely wound coils. Tightly wound coils of these dimen-

sions would weigh approximately 27,000 lbs. per load. It is estimated that such a load would require 14 hours heating time and 140 kwh. per net ton. The output would be about 24 net tons per day.

Since these furnaces employ retorts or hoods, the heating chamber may be removed immediately when temperature has been reached, and put on another load. The retorts permit the use of coke-oven gas for atmosphere, which may or may not need purification, depending on its condition, and the surface requirements of the product. Atmosphere from the combustion type producer, previously referred to, may also be used, and the increase in volume obtained will generally result in lower cost, and eliminate the explosion hazard.

It is well known that most of the annealing equipment in steel mills is out-of-date, and that comparatively little improvement has been made in annealing equipment throughout the extensive development which has taken place in other lines of steel mill equipment.

The final heat treatment of a product, however, is quite as important in determining its value to the user and its marketability, as any other process employed in its manufacture. This is particularly true of high grade products, such as alloy steel bars, carbon steel strip, silicon steel sheets, etc., and it is significant that the manufacturers of these products have found it economical to install the best heat treating equipment available. More rigid specifications for sheet and strip products may require closer study of these processes also, in the not far distant future.

While some of the methods proposed herein may seem radical to steel mill engineers, it is believed that the principles are sound, and that the future is likely to see their embodiment in production equipment on a large scale.

Temperature Distribution of Electric Furnaces Compared to Fuel Fired Furnaces

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Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

Practically everyone admits the necessity for better heat treatment. The choice of equipment, fuel versus electric, is becoming more controversial each day, particularly due to the inroads electric furnaces are making in the steel mills. The electric people use the same specific argument applied many years ago by the motor application engineers, that the cost of electric power may be more than that of gas, coal or oil, but that the advantages obtained are well worth the differences in such costs.

But it is evident that in order to be convincing, we must have FACTS, not merely hearsay evidence. The manager of a mill says "We use fuel furnaces, and are getting satisfactory results, therefore why change?" Or he may say "We appreciate that we need new furnaces, but why can't I get just as good a product in a high grade fuel furnace as I can in a high grade electric furnace?"

An investigation was made of a dozen or more prominent electric furnace installations to determine the economic advantage of electric furnaces over fuel furnaces. In every case it was found from tangible results, almost all of which were obtained directly from the books of the respective companies, that the electric furnace installations paid for themselves in savings in from six months to three years time.

However, despite this evidence, there was always the thought in the mind of some new prospective user that such a condition did not apply to his particular product, and that, anyway, the fuel furnace may have been obsolete in design, or in poor condition.

Not discounting the value of the economic or commercial analysis of such installations, as such data is invaluable at certain stages of development, the fact remains that this does not answer the two questions above stated, which questions now present themselves quite frequently.

In order that we might know the correct answer to these questions, in as unprejudiced and unbiased a manner as it is possible for representatives of electrical manufacturing companies to be, we solicited the aid of several high grade combustion engineers, metallurgists, and other disinterested parties, and through the courtesy of several large representative

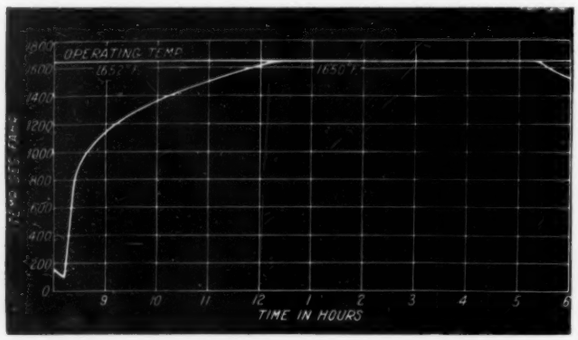

FIG. 1

plants, proceeded to find out all we could about the heating characteristics of fuel and electric furnaces.

The first step in carrying out the research work outlined herein, was to have available for experimental and practical tests a number of furnaces now in use in connection with many phases of heat treatment.

The second requirement was to be assured that such furnaces were representative of their respective types, that they were in good operating condition, and that the results obtained from them would be indicative of the best practices of today for each type and each application.

Thirdly, it was necessary to select places for tests only with such companies of national reputation as demanded a high grade product, had metallurgical staffs to set standards of heat treatment and make suitable tests on materials, were satisfied as to the performances of their furnaces as producing everything that could be desired, and had competent engineering and maintenance staffs to keep the furnaces in the best of operating condition.

Due to the nature of this work, and the many astonishing things disclosed, the names of the plants where the furnace tests were made cannot be divulged. Reasons for this become evident as study of the separate tests divulge the non-uniformity with which the charges were heated.

Each test was conducted in an unbiased manner, the entire purpose being to obtain facts. Wherever any question arose as to the ability of the furnace to perform in a better manner, such tests were repeated, and only the best performance was selected as being representative of the particular furnace.

Care was taken, in each case, to have the furnace loaded with an average charge, neither heavy nor light. Engineers and metallurgists of each company were present and were satisfied that the operating condition was normal in every respect, and that the thermo-couples were correctly placed with respect to various parts of the charges.

In several instances, combustion or fuel furnace engineers expressed the opinion that the performance of the furnaces might be improved if changes were made in the construction of the furnaces or burners and the tests repeated; the final results to be accepted as representative of the furnace performance. This was always done.

In one instance, a fuel furnace builder was given permission to completely rebuild one of the furnaces, or as much of it as he considered essential to secure the best performance. The final result of this test was accepted as being representative furnace performance.

There were more gas furnaces tested, and more tests made on the same gas furnace, than on electric furnaces. The reason for this was the attempt to find, reconstruct, or otherwise produce, if possible, a gas furnace which would give correct temperature distribution.

A potentiometer pyrometer was used throughout

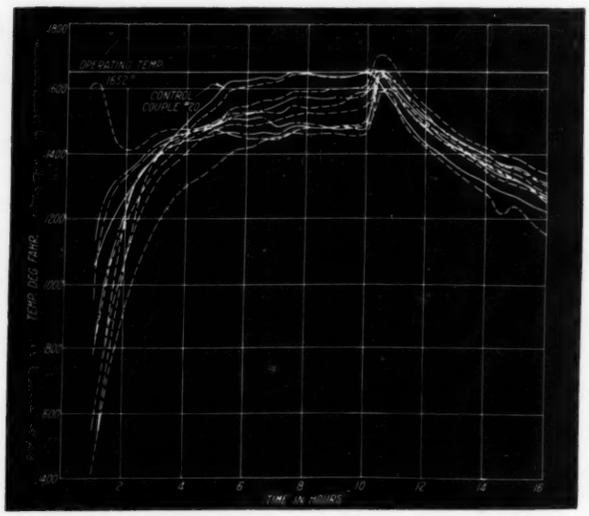

FIG. 2

the tests. This consisted of a portable potentiometer indicator, reading in millivolts. The potentiometer was read to within one-tenth of one division, plus or minus, giving an accuracy of reading equal to that of the instrument itself.

Thermo-couples were made of 0.0253 inch diameter chromel-alumel wires welded together. These consisted of a special product made for the Westinghouse Company. Each 500 foot lot of thermo-couple wire was tested in the laboratory to insure accuracy of results.

Allowing for accumulative errors which may occur, the records of these tests are accurate within 1.5° F., plus or minus. Such errors were due to limitations of equipment, and not to the reading of the instruments, since means could have been taken to read the instrument within one-twentieth of a division if desirable.

In reviewing the following tests, it should be borne in mind that the location of the furnace controlling thermo-couples has no effect upon the temperature variation within the charge. Changing the location of the thermo-couples or changing the control setting of the controlling instrument may either raise or lower the temperature test curves as a mass, but can have no effect on individual curves.

Wherever possible, the thermo-couple was im-

bedded directly within the material heat-treated. The very fine wire permitted the entire thermo-couple being inserted in a 1/8" hole. In cases where the drilling of a 1/8" hole would irreparably damage the material and thereby cause undue loss, test blocks, of the same material heat treated and of the same cross section were made up, drilled to the center, and the couple inserted.

A great many tests were made, and many of them repeated due to the user's temporary inability to accept the results as being the true performance of his furnace. A second test was always convincing. It is impossible to select from these tests, extending over a period of two years, but a very limited number for discussion.

An opportunity was presented to make a test on a car type gas fired furnace used in normalizing steel castings. This furnace was nine months old, was acknowledged to be in first class condition, and

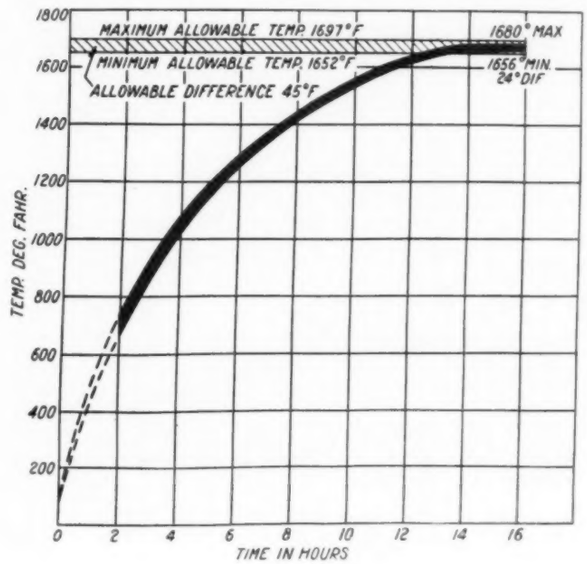

FIG. 3

was offered as being an example of high grade performance. In fact, we were told that it was the equal of any electric furnace in performance, and operated at one-half the cost.

The furnace was provided with automatically controlled valves, actuated by a pyrometer. Figure 1 is a reproduction of the temperature control chart, indicating that the charge came up to 1650° F. in four hours, and was held at that temperature for five hours.

Without going into a prolonged recital of what took place over a period of three months time, during which time six temperature exploration tests were made on this furnace, Fig. 2 shows the result of the sixth and last test made on the car type gas furnace in connection with which Fig. 1 is the supposedly heat treatment of the charge.

Between the period of the first and last test, practically everything was done to the furnace possible of accomplishment to improve its performance. In addition, the charge was reduced from 16000# to 9000# to give a better load distribution.

Eighteen thermo-couples were used in this test, the illustration only showing one-half or the odd numbered couples. Each thermo-couple was embedded in the center of a block of steel casting having a section 4"x4"x12" long, thus eliminating the possibility of indicating flash or surface temperatures.

For a soaking period of four hours, temperatures throughout the charge remained practically constant, and each section of the charge had reached saturated conditions with respect to this particular charge and this particular heat. Parts of the furnace that were hot remained hot, and parts that were cold remained cold. The temperature variation was 200 degrees F. Only 1/17 of the entire charge came within the temperature requirements and the metallurgical requirements, as shown by test samples taken from each of the cast blocks in which the thermo-couples were embedded.

A phenomenon occurred during this series of tests, which was very startling, but which have later been observed several times. That is, an increase in temperature **after,** the gas was turned off. Readings were taken every 30 minutes, hence the exact time of the beginning of the increase in temperature after the gas was entirely cut off was not observed. Bearing in mind that the thermo-couples were embedded 2" under the surface, the performance is startling. Grain structure and metallurgical test results all checked with the temperatures as recorded.

In this same plant there was a large electrically heated car type furnace used for relieving welding strains of structural shapes. A car load of steel castings were heat treated in this furnace, with a test conducted in exactly the same manner as in the previous gas furnace, with the exception that the charge weighed 20,000 pounds instead of 9000 pounds.

Figure 3 shows the result of the test. The entire charge came up to within 12° F. plus or minus of the desired temperature. The tensile strength of the test samples varied from 73,000 to 75,000 pounds per square inch, as against 50,000 to 75,000 for the gas furnace test.

A comparative machining cost analysis was made by the Cost Analysis Department, and from their report, there was a saving in machining cost of $25.60 per ton. On the basis of heat treating a

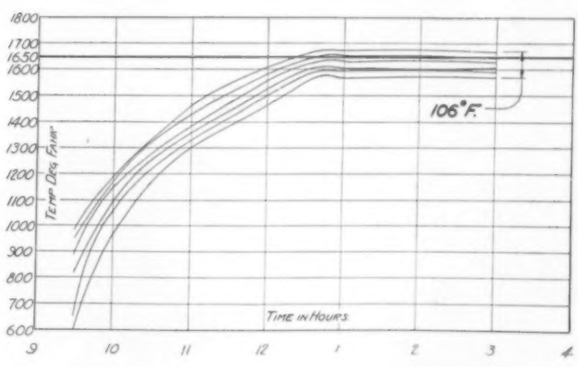

FIG. 4

16,000 pound charge each day, with natural gas at 30 cents per M. and electricity at 1 cent per K.W. hr., it cost $14.40 to heat with gas and $22.40 with electricity. But the saving in machining costs was $204.80.

A well known builder of gas furnaces came into

a plant, and stated that they would be willing to take one of the present fuel furnaces, completely rebuild it, and show just what was possible of accomplishment in a properly designed and constructed gas fired furnace. Out of a group of 14 large box type furnaces, the furnace builder was permitted to choose one for his demonstration.

The rebuilding of this furnace was accomplished over a period of almost six months' time, during

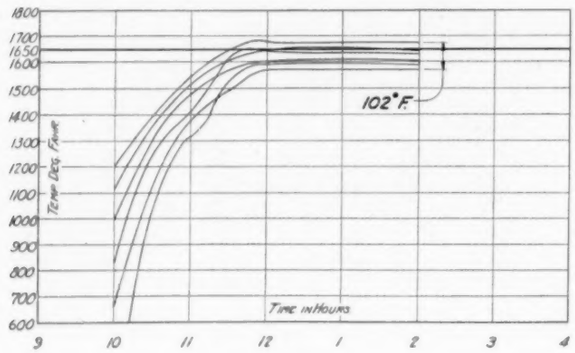

FIG. 5

which time the interior of the furnace was torn down and built up several times, and many different combinations of burners used.

Prior to the beginning of this remodeling, a temperature exploration of the furnace was made with the results as indicated by Fig. 4.

A final test made on the furnace after it was announced by the furnace builder that he was ready for a test. After six months' work, they had succeeded in bettering the temperature distribution by 4 degrees F., as shown by Fig. 5.

A fuel furnace builder stated that they had a furnace in operation in a neighboring plant that was operating within 5 degrees F., plus or minus, throughout the entire charge. This furnace was supposed to represent the latest development in fuel furnace design. The furnace was under and over fired, gas heated, with automatic temperature control. Permission was granted by the user to make a test on this furnace, with the result as shown in Fig. 6. A variation in temperature of 112 degrees F. was recorded in the charge.

Three box type electric furnaces were in use in a plant for heating of tank headers preparatory to forming. These furnaces were somewhat larger than the gas furnace previously referred to in Fig. 6, and were 9'x9'x2½' high inside dimensions. These furnaces are shown in Fig. 7.

A test was made on one of these electric furnaces, and the result plotted on the same paper with the gas furnace test, for comparison. Test pieces were placed 8" from each corner, 8" from the rear wall, center, and 8" from the door vestibule, and in the center of the furnace chamber, all in duplicate, that is to say, at floor level and elevated 12 inches. The maximum difference in temperature was 6 degrees F from the pyrometer control setting, as shown in Fig. 8.

The basic principles of heat generation and heat liberation of furnaces as developed by this investigation may be stated as follows:

The source of energy used for heat treatment of metals must be capable of being liberated throughout a furnace chamber in such a manner as to bring the entire charge to a uniformity of temperature such as required to obtain highest standards of quality without rejects.

The temperature and location of the heating medium must be such that during the heating period no part of the charge will reach a higher temperature than permitted by the metallurgical requirements while the heating of the center of the charge is in process through conduction of heat from the surface.

Due to furnace construction, the door openings cannot be as effectively heat insulated as other parts of the furnace, with the result that the radiation losses from a furnace are not constant for each square foot of exterior surface. Therefore, the source of heat used must be such as to cause to be liberated at such points a definite additional amount of heat energy, sufficient to compensate for such losses. In no other way can a uniform temperature condition be maintained within the furnace chamber.

The conditions within a gas furnace, which were found to be at variance with the above developed principles, are listed herewith:

1. Despite the number of burners in a furnace, the heat is generated at relatively few points as compared to a resistance type electric furnace. This results in hot and cold spots throughout the furnace chamber.

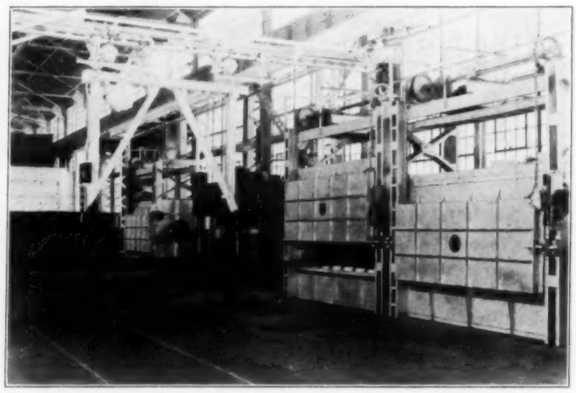

FIG. 7

2. The greater the temperature gradient between the charge and the heat source, the more difficult it becomes to control the heat distribution. The ideal condition would be that in which every square inch of the furnace surface liberated heat at just a few degrees above the temperature required by the work. The worst condition would be an attempt to heat a furnace from one point only, such as with an electric arc. Flame temperatures as high as 2,700° to 3,000° F. are used, despite the fact that the temperature desired may be anywhere from 1,600° F. down to a few hundred degrees.

3. The setting of the gas burners vary from a week to week. There is no assurance, even with constant gas and air supply, that the conditions existing in a furnace today will be duplicated next week or next month.

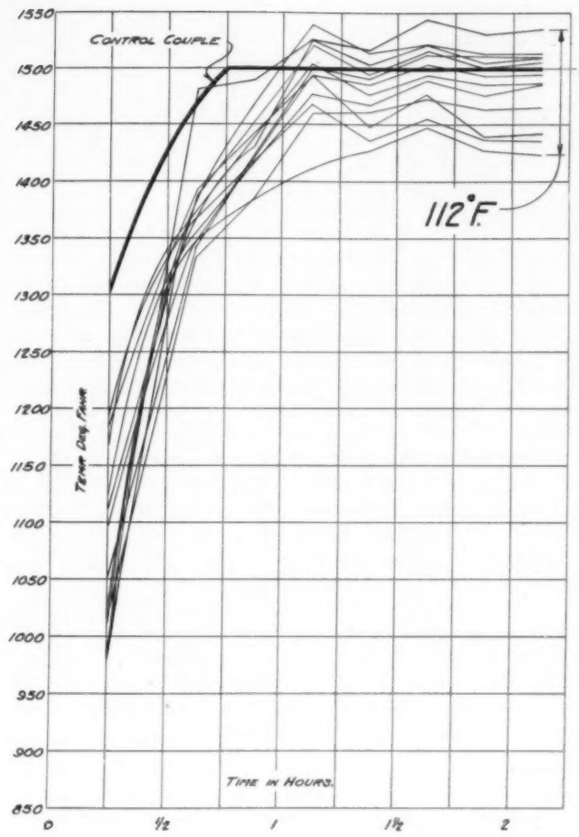

FIG. 6

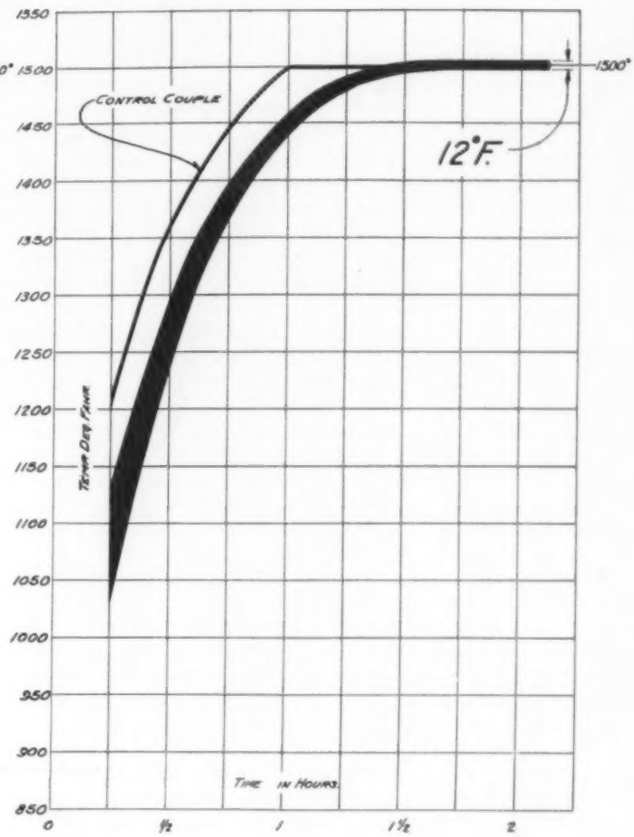

FIG. 8

4. Convection currents play an appreciable part in the heating of a charge in a gas furnace. Repeated tests showed that after each new charge was placed in a gas furnace, an entirely new condition was created. Locations which on the previous tests were cold, became hot, and other points which had been hot, became comparatively cold. Sometimes these conditions seem to be created by the shape of the charge and the manner in which the convection currents swept around it, and other times it seemed wholly a matter of chance as to the manner and direction in which the hot air currents were started.

5. In view of this influence of convection currents, the temperatures of the gases will vary considerably within the furnace chamber, hence the temperatures of the charge likewise will vary. The temperature of the blast of gases leaving the burner and when coming for the first time in contact with the charge, may be several hundred degrees higher than when, a little later, these same gases pass over another portion of the charge on the way to the exit port. The charge nearest the exit ports cannot attain the same temperature as that part near the burners or entrance ports.

These characteristics of gas furnaces constitute the major inherent difficulties to be overcome before such a furnace can be made to produce dependable uniform temperature conditions within the charge of material being treated. The main improvements in gas furnaces during recent years consist in increasing the thermal efficiency of fuel consumption, and the general design and construction of the brick work, together with the adding of automatic temperature control. Beyond this, the securing of the one thing a furnace must accomplish in the future, uniformity of heat distribution within the charge, appears not to have been accomplished.

In marked contrast to the tests made on the gas furnaces, every test made in the electric furnaces showed a uniformity of temperature well within the specified limits for producing the ultimate in the physical properties required by the particular materials being heat treated. Repeated tests gave substantially identical results. There seemed to be no doubt that the heating conditions in such furnaces could be regarded as fixed and non-changing, insofar as heat generation and heat liberation were concerned.

The inherent characteristics of electric furnaces, as determined by this investigation, may be outlined as follows:

1. Heat may be generated and liberated within a correctly designed electric furnace so as to heat the charge uniformly.

2. The heating conditions are non-changing. Every square inch of the heating element liberates a definite amount of energy in the furnace. Changes in voltage affects this only as a mass, and not locally.

3. Heaters may be located in a furnace as to permanently compensate for all losses, such as around the doors, around sand seals, or any part of the furnace or charge which tends to be cool. Each of the four electric furnaces tested, one a large car type, one a large pit type, and two large hearth type fur-

naces, presented difficult problems in heat distribution and in compensation for losses, which problems were solved in a thoroughly satisfactory manner.

4. The maximum temperature of the heat source is very much lower than that of the gas furnace, and may be only 50 or 100 degrees above the final temperature of the charge.

5. The conversion of electrical energy into heat energy is an exact mathematical conversion, so that once the heating elements are properly located within a furnace to liberate the heat uniformly to the charge, these conditions are fixed and are non-changing.

6. The electric furnace is a machine of definite heating characteristics, and may be depended upon to produce a definite product each time.

7. An electric furnace may be designed to produce the ultimate in whatever physical property the charge is capable of producing, and this same property may be obtained throughout the entire charge.

The following conclusions are believed to be an accurate analysis of the results of this investigation. The facts virtually speak for themselves.

There is an amazing lack of knowledge on the part of industrial plants as to the exact temperature conditions of metals being heat treated. The use of automatic temperature controls on furnaces has created a false impression as to its function and as to results. Such equipment responds only to the temperature of the thermo-couple actuating the control instrument, whereas a few feet away from that thermo-couple, the temperature may be 25, 50, 100 or even 200 degrees higher or lower.

In every case, where fuel furnaces were used, the test tolerances were so set as to allow practically all of the product to pass the shop tests, otherwise an excessive rejection would have resulted.

In every case, where the product was improperly heat treated, the user of the furnace was penalizing himself by an increased factory cost in other departments, such as increased machining costs, excessive breakage of materials and tools, increased labor in working or forming the metals, or the scrappage of partly or completely formed parts which was taken as a matter of course, and seldom traced back to the heat treatment as the cause for the loss and difficulties experienced. Evidence was secured, showing that engineering designs of the product had been changed for the purpose of enlarging the parts, to eliminate breakage which had occurred in the field. These changes were due entirely to the fact that the tensile strength of those parts was not uniform, as disclosed by these tests, and resulted from the non-uniformity of heat treatment.

Every charge heat treated in the electric furnace, met, in its entirety, the metallurgical requirements. Physical and photo-micro tests corroborated the fact that the entire charge was being heat treated at the proper temperature to secure the maximum in physical properties from the metals.

Discussion

Discussion presented by

H. G. Gibson, Chief Engineer, McKeesport Tin Plate Company, McKeesport, Pa.
Wirt S. Scott, Special Representative, Industrial Heating Div., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
J. B. Brunot, National Tube Company, Ellwood City, Pa.
A. N. Otis, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.
F. E. Leahy, Fuel Engineer, Youngstown Sheet & Tube Company, Youngstown, O.
H. R. Belding, Metallurgist, American Sheet & Tin Plate Company, Vandergrift, Pa.
Lee Wilson, President, Lee Wilson Engineering Company, Cleveland, O.
C. E. Gifford, Works Metallurgist, American Rolling Mill Company, Zanesville, O.
Glenn Coley, Detroit Edison Company, Detroit, Mich.
G. S. Warren, Chief Engineer, Sharon Steel Hoop Company, Sharon, Pa.
M. H. Mawhinney, The Electric Furnace Co., Salem, O.
W. Anderson, Engineer, General Electric Company, Pittsburgh, Pa.
T. W. Jenkins, Youngstown Sheet & Tube Company, Youngstown, O.
H. Plott, Youngstown Sheet & Tube Company, Youngstown, O.

H. G. Gibson: I'd like to ask a question on the first paper presented this evening, regarding the tests made on gas fired furnaces—Do they apply to batch type furnaces only, or to continuous types as well?

W. S. Scott: The tests that I showed were on furnaces of the batch and car type. I have made several tests on continuous furnaces but these were relatively incomplete as compared to the batch and car type furnace temperature distribution tests I have made.

The length of these furnaces, the handling of the thermocouples and the movement of the thermocouples through the furnace make it a very difficult job to run a temperature exploration test on a continuous furnace. I would expect the temperature distribution in a continuous furnace to be somewhat better than in a batch or car type furnace and as a matter of fact, I found it so. However, I do not believe the distribution is nearly as good as generally supposed. In a certain furnace I tested having a hearth 42" wide, I found a variation in temperature of the work within the final heating chamber of 100 degrees F. This was not an instantaneous temperature difference across the hearth, but rather was a difference in temperature of two different pieces of steel of the work progressing through the furnace; one thermocouple being approximately 4 feet in back of the other one and 2 feet towards one side. The final difference in temperature was measured when the thermocouples reached a definite point in the furnace and at the point of their highest temperature, or at the end of the soaking temperature.

Since the controlling device controls the temperature only at the point of thermocouple and since a furnace has some height and breadth to it and since

the thermocouple is usually located at some distance above the work, it follows that the temperature of the work directly under the thermocouple need not be at the same temperature as the thermocouple and that the work to the right or the left through a distance of 2 feet may be considerably higher or lower in temperature than that of the thermocouple.

J. B. Brunot: In Mr. Otis' paper concerning the annealing of sheets in an electric furnace, he said that the atmosphere was about 6% each of hydrogen, CO and CO_2, and the balance nitrogen. I would like to ask the manner for drying that gas before introducing it into the furnace chamber.

A. N. Otis: The equipment has a built-in condenser, that is, a water cooler which dries the gas to tap water temperature. Now, with coke oven gas, which consists of about 55% of free hydrogen and much of the remainder hydrocarbons a considerable amount of water vapor is given off in the combustion. The water vapor should be removed to make a gas that is suitable for bright annealing operations. In the winter, of course, the gas will be dryer than in the summer, due to colder water, but the gas, if cooled with tap water at a temperature of around 60 degrees Fahrenheit, is okey for bright annealing operations. There might be too much moisture for annealing high carbon steel, due to the possibility of decarburization, but it's all right for bright annealing. The condenser is built right into the apparatus. Does that answer the question?

J. B. Brunot: Yes.

F. E. Leahy: After seeing some of the data presented here, I think a lot of operators must be wondering how they turn out a good product with a gas fired furnace. I know that a number have made graphs in very much the same way as shown here, and have had results that approximated very closely some of the results read tonight.

Is there anyone here from the American Sheet & Tin Plate Co.—the Vandergrift plant? I believe they have an electrically fired annealing furnace of the type described here.

H. R. Belding: I'm connected with the Vandergrift Works of the American Sheet & Tin Plate Company, and we have electric and gas furnaces. We have these temperature differences in gas fired furnaces that were spoken of tonight; and, as far as control goes, we favor the electric.

F. E. Leahy: Do you use those furnaces for anything except a special grade of annealing?

H. R. Belding: No, nothing but the special grade.

F. E. Leahy: Is there anyone using an electrically fired annealing furnace on a grade other than the silicon steels? I would like to ask Mr. Lee Wilson if he has anything to say.

Lee Wilson: I might say this, Mr. Leahy, that possibly in the last two years the trade has realized to a large extent what Mr. Scott has said about the higher temperature at the burners, causing spot heating. Possibly that is the reason for the swing in a good many cases in fuel fired furnaces to a luminous flame, which does to a certain extent eliminate that difficulty.

F. E. Leahy: Well, judging from the papers read by Mr. Scott and Mr. Otis it would appear that using any other method of heat transfer except radiation would subject you to a wider variation in temperature than you would get if you used that method only. I believe there has been some recent development in gas fired furnaces where they are firing through tubes in which the heat transfer would be more by radiation than any other of the mechanisms, and I thought that possibly there might be someone here with experience along that line.

C. E. Gifford: In one of Mr. Otis' slides showing the charge of steel, the sides were very flat, but I noticed an upward curve on the ends. I wonder if he has any particular explanation of that.

A. N. Otis: No; I haven't, Mr. Gifford. I have generally found, in annealing these loads, that the sheets are somewhat thicker at the middle, and in that particular load there was a thermocouple stuck in the end. I might say also that that photograph came from Italy. That furnace is installed in Italy. In fact, it's the first furnace anywhere, that I know of, outside of General Electric plants, that was equipped with the recirculating cooling system, and it's installed in Italy. I don't know whether that offers any inspiration to you or not.

Glenn Coley: I'd like to ask Mr. Otis if this combustion apparatus he showed can be used with producer gas?

A. N. Otis: Mr. Coley, the combustible elements in producer gas are quite low. It hasn't enough combustible elements in it to maintain the temperature of the apparatus where we want it, and, furthermore, it is largely composed of CO which burns to CO_2 and we don't want a high CO_2 product. Now as a matter of fact some people are using producer gas just as it is—cleaned and scrubbed but without burning. It probably won't do for high carbon products, but it will give a bright anneal used just as it is. One objection would be that it has higher inflammable properties than burned coke-oven or burned natural gas. The CO content is about 28%, as I recall it. So it's not as safe a gas as the burned gas. There would be comparatively little if any advantage in burning it.

F. E. Leahy: I would like to ask a question, Mr. Otis. When does it become necessary to use a dryer such as activated alumina in the drying of gases for atmospheres, for control purposes?

A. N. Otis: We have run across only a few occasions. One is for annealing high silicon electrical steel where the moisture content is likely to oxidize the silicon in the steel at higher temperatures. That problem has had a good deal of study, and there are no definite recommendations which could be made on it at this time. There are probably some applications for high carbon steel where it would be of advantage to have a dry gas, particularly where long annealing cycles are to be employed; that is, in a large furnace, say, holding ten to twenty tons or more of alloy bar stock on a long cycle. It would be desirable there to have a dry gas, due to the decarburizing effect of moisture. The necessity of a very dry gas is rare.

G. S. Warren: I'd like to ask what is done with the heat you take off with the water. Why don't you use the heat you take off in the cooling water to heat another batch of steel?

A. N. Otis: And put it in another furnace?

G. S. Warren: Yes.

A. N. Otis: It might be possible to do that, but

it would require two furnaces, and add some complication. It is difficult enough to sell single furnaces.

G. S. Warren: But it would raise the efficiency —reduce the waste.

A. N. Otis: There might be some possibilities in that direction.

G. S. Warren: Two together doesn't cost you as much as two single ones.

F. E. Leahy: Is there any discussion of Mr. Mawhinney's and Mr. Bechtel's paper on the batch firing practice? Any question about it? I had the opportunity of seeing one of their installations just recently and it was quite interesting to see the speed with which they could unload and load and recharge one of their car type furnaces and get it going. I think it didn't take much over five minutes. It was almost a continuous operation and it was done with very little labor and apparently at quite a low cost. I thought that this paper also would bring out quite a little discussion. Is there anyone here that has such an installation? The installation that I saw was at the National Tube Company at Ellwood City. We might ask Mr. Mawhinney how close his temperature range is.

M. H. Mawhinney: I'd like to say something about that. I think that Mr. Scott's comparisons have been with what we call the "direct fired" furnace in which the burner fires through a port in the wall, coming in contact with the steel. For heat treating purposes we, or very few of the other fuel fired furnace builders, use that type of furnace. What we do use is the indirect furnace where we fire in a combustion chamber above or below or to one side of the load, and then distribute the gases at low velocities symmetrically around the load. The result of such arrangement is temperature uniformity within—well, easily thirty degrees total variation at all times. And if they didn't we wouldn't be paid for the furnaces we build in most cases. So I think that therein lies the unfavorable comparison of the fuel fired furnace with the electric furnace—the comparison with the direct fired furnace.

W. Anderson: I'd like to have the speakers' comments on the present status of continuous electric annealing for fairly wide strips.

A. N. Otis: Furnaces have been laid out for continuously annealing strip. We have worked out a design which several of our steel mill friends have examined, and they haven't found any objections to it. The figures, as I recall, would be a travel speed of about 60 feet a minute; the capacity, about 50 tons a day, of 30-inch wide tin plate strip. It is a counterflow type, with heat recovery, annealing in an atmosphere that protects the material. It would be annealed bright, and use about 65 kilowatt hours per ton. That is considerably less than half the energy that would be used in a straight through annealing furnace, the saving being due to the heat recovery feature.

T. W. Jenkins: I believe it would be interesting to the group here if Mr. Otis would tell us something of what has been accomplished in controlled cooling in continuous type, controlled atmosphere, normalizing furnaces.

F. E. Leahy: The rate of cooling, is that what you mean?

T. W. Jenkins: Or variations in rate that can be accomplished.

A. N. Otis: Mr. Chairman, we have made studies along that line also. As I outlined in connection with experiments on stacks of sheets, it takes a long time to get started with these large applications, and to get the data. It takes time also to study and correlate it. You've got to have a furnace of large enough size, and that means considerable investment. There's little gained in working on small pieces; what we're interested in is full sized sheets. It takes a long time, particularly under prevailing business conditions, to sell such a furnace, and to get data together and correlate it on those subjects.

We have treated lots of samples for customers—that is normalized continuously in small continuous furnaces. We have gotten samples of deep drawing sheet which had excellent physical properties—we have taken hot rolled sheets, normalized them and reduced the scale in one operation. That work has been done and designs have been laid out for controlled cooling as you suggest, Mr. Jenkins, with a recirculating system similar to that outlined in the paper for the box type furnace. Without going into the details of the arrangement, I might say that it is very effective in extracting heat. For example, in the continuous furnace for strip referred to a few minutes ago, the strip would leave the furnace at about 600 degrees; but at that temperature it would oxidize, of course. Now we have calculated that, with a properly designed forced cooling arrangement, the strip could be cooled from 600 degrees to 300 degrees in a chamber about seven feet long. That figure may be off, but it's not very far off. It may be eight or nine or ten feet long. That shows the tremendous rate at which heat can be extracted, particularly from a thin sheet which will yield it. Those principles could be applied to a sheet normalizing furnace, or to a strip normalizing furnace and quite complete studies have been made along those lines.

C. E. Gifford: A while ago you gave a figure of 65 kilowatt hours per ton for annealing. To what temperature was the annealing carried under these conditions?

A. N. Otis: About 1400 degrees Fahrenheit.

H. Plott: I would like to ask Mr. Otis in determining these various atmospheres for treating sheets, do you ever find any evidence of absorption of nitrogen by the sheets?

A. N. Otis: There is some evidence that silicon steel will absorb nitrogen at very high annealing temperatures. We know it will absorb oxygen above a certain temperature, and the oxygen may combine with other elements present. I am not prepared to say whether ordinary steel will absorb nitrogen in annealing, because I don't know of any experiments along that line. The amount of absorption would probably be a function of time and temperature. For ordinary steel the annealing temperature is low, and the time long, while for normalizing the temperature is high but the time short. Apparently there would be little likelihood of nitrogen absorption in either case.

H. Plott: I have seen where the punching quality of the sheet was very much affected by nitrogen—or at least that's what it was attributed to, although we have found no evidence under a microscope of a nitrite present.

A. N. Otis: It might be due to oxygen. What temperature?

H. Plott: Seventeen or eighteen hundred.

A. N. Otis: It could probably absorb oxygen at that temperature.

H. Plott: Of course, it was in an atmosphere that carried some oxygen.

A. N. Otis: Could it have sucked in air through the seals when it was cooling?

H. Plott: Well, there was some nitrogen present too.

A. N. Otis: That, I think, is a fair conclusion as I understand the reaction.

Lee Wilson: I have discussed with several steel men the possibility of annealing tin plate in continuous furnaces, and the big drawback they all bring up is the question of handling cost on a small pack. I was wondering if Mr. Otis had been working on anything of that kind that could be helpful, or if there is an explanation as to why so many people think the handling cost is going to be high, or possibly why they think it's going to be low, or something along that nature.

A. N. Otis: I might say that furnaces of the continuous type could be built for packs of large or small sheets. There is no particular difficulty involved in building a furnace for those requirements. The thing that you'd have to determine is what are the requirements to give the lowest cost, on which we couldn't very well help you.

F. E. Leahy: Mr. Otis, do you have anything in closure?

A. N. Otis: I wish someone would offer some criticisms or comments on these methods of cooling, but I have nothing to add except that I might say a few words in confirmation of the results which Mr. Scott has shown in his paper. For example, in annealing coils of steel wire, we have gotten temperatures from top to bottom of a stack within five degrees Fahrenheit—that is, in a furnace with a circulating fan to keep the gas in motion. Five degrees is very close, but we have run load after load with temperatures within five degrees total range.

And, again, about the distribution of temperature across the hearth of a furnace. We have had occasion to check that in connection with the annealing of bars. We set up a test with a layer of 2-inch diameter bars. This particular operation was a drawing operation at 800 degrees, and the customer wanted to be satisfied that the outside bars—those near the edge or the furnace walls—would not be overheated. He wanted to know to what extent they would overheat, and what the temperatures would be across the layer when final equalization had taken place. Now we set up tests in two different kinds of furnaces with different heat distribution, and, believe it or not, the temperatures came within two or three degrees of 800 as the final temperature. Now they weren't as close all the way up as Brother Scott's curves,—I guess he has us beat on that,—but we were closer when we got through. We were within three degrees.

F. E. Leahy: Mr. Mawhinney, do you have anything to say in closing?

M. H. Mawhinney: I don't believe there is anything further to add, Mr. Leahy. I will say again that the fuel furnace can be heated uniformly both at low and high temperatures if fired indirectly. I repeat that statement.

F. E. Leahy: Mr. Scott, do you have anything further you would wish to add?

W. S. Scott: Mr. Chairman, I don't believe I have anything further to add.

AMERICAN IRON AND STEEL INSTITUTE NOTES

Payrolls in the steel industry in May reached a new post-depression high of $51,895,931, an increase of $6,424,053 over April, according to figures announced by the American Iron and Steel Institute. At the same time, it was revealed that 18,276 more people were employed during the month, bringing the total number of employees up to 449,362.

The number of wage earners, i.e., workers paid on an hourly, piecework or tonnage basis, increased 17,629 during the month to 409,698. This is slightly more than 97 per cent of the total employed at the 1929 peak and is 104,459 more than were employed a year ago. Total wages for this group increased during May by 16.6 per cent to $42,916,172.

The average hourly wage per worker in May was 64.6 cents compared with 47.3 cents in June, 1933. The average hours per week for each wage earner during May was 36.6 compared with 33.7 in April and 39.4 in June last year.

Average hours per week for all employees, including those on salary, was 37.1 and the average hourly wage rate was 70.3 cents, making an average weekly income for all employees of $26.08. Total hours worked by wage earners increased from 56,723,813 in April to 66,450,593 in May. During the same period the industry's operating rate increased from 54.19 per cent of capacity to 58.06 per cent.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ELECT OFFICERS

J. Allen Johnson, chief electrical engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y., was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1934, as announced at the annual meeting of the Institute held at Hot Springs, Va., during the annual summer convention of the Institute. The other officers elected were: Vice presidents, W. H. Timbie, Cambridge, Mass.; R. H. Tapscott, New York, N. Y.; G. G. Post, Milwaukee, Wis.; F. J. Meyer, Oklahoma City, Okla.; F. O. McMillan, Corvallis, Ore. Directors, F. Malcolm Farmer, New York, N. Y.; N. E. Funk, Philadelphia, Pa.; H. B. Gear, Chicago, Ill. National treasurer, W. I. Slichter (re-elected), New York, N. Y.

Characteristics of Temperature Controls For Oil Fired Furnaces

By W. N. HORKO
Electrical Engineer, Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.

Presented before the Philadelphia District Section of the A. I. & S. E. E. April 7, 1934.

The purpose of this paper is to show how a bank of oil fired file annealing furnaces were improved by redesigning the combustion chambers using a modern hearth material and the results obtained using different types of automatic control.

Oil fired furnaces built 15 or more years ago did not have the refinements of design and control which the modern furnace has. In many cases they consisted merely of a fire brick shell and a hearth of the same material. It was expected that the fire brick side walls would retain the heat within the furnace and that the same material used in the hearth would act as a medium of heat transfer. Even today many oil fired furnaces are built without much thought of insulation or temperature control. Should the proper consideration be given these features in the design of an oil fired furnace they could, in many cases, compete strongly with furnaces using the high priced sources of heat.

A general view of the furnaces to be discussed in this paper is shown in Fig. 1. These furnaces had fire brick hearths approximately 5x5 feet. The

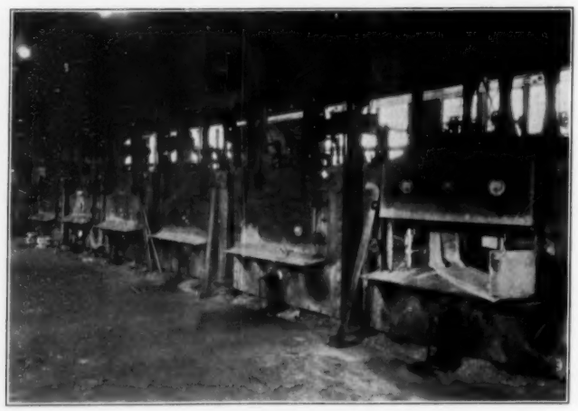

FIG. 1

hearths were originally supported on three solid fire brick piers extending nearly the full depth of the furnace and located directly in front of the burner ports. In addition to the three solid piers there were several spot piers located along the side walls. These spot piers acted as additional supports for the hearth. The hearth withstood a load of 3000 lbs. which was divided equally on two trays of the type shown in Fig. 1.

The firing equipment consisted of three low pressure air-oil burners of the two inch size which passed 5 gals. per hour per burner during the heating up period and approximately one gal. per hour per burner during the holding period. Two burners on 20 inch centers fired from the rear and one from the front center of the furnace. The burning gases from the burners pass into the annealing chamber through openings at the sides and rear. From the annealing chamber the gases pass through checker work in a

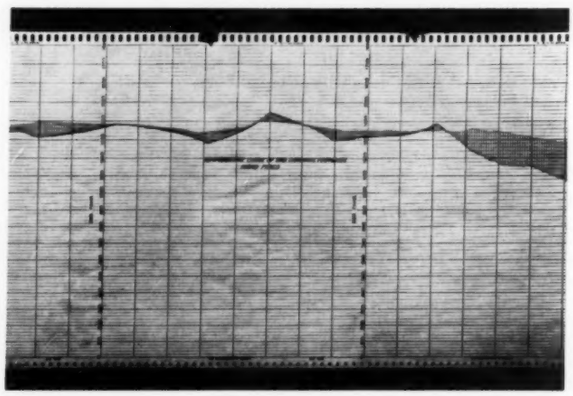

FIG. 2

false arch and then spread between the false arch and the outside roof through which they pass into the atmosphere by means of four 6x6 inch openings in the corners. The furnaces are fired every other day. The intervening day being utilized for unloading and reloading.

Several years ago an investigation was started with a view to improving the operating conditions and temperature uniformity of these furnaces. The operating conditions were poor chiefly because of the improper combustion chamber design. As previously described, the hearth supporting piers were placed directly in front of the burner ports and were probably intended as breakers which would assist in diffusing the burning gases within the combustion chamber; thereby heating the furnace more uniformly. In reality these piers had the opposite effect in that they acted as a nucleus for the formation of carbon. This carbon formation grew very rapidly and eventually blocked the passage between the piers. This resulted in a concentration of heat in front of each burner and a hot spot in the hearth directly over each carbon formation. At this time it became very necessary to chip away the carbon. In doing this the supporting piers were usually damaged and hearth sag and premature failure followed. The hearth life was six months when used in the regular way at 1400° F. Occasionally these furnaces were used for carburizing at 1700 degrees. Under this condition the hearth averaged four heats.

It was decided to redesign the combustion cham-

ber in order to improve the operating conditions. This was accomplished by dividing the chamber into three equal parts by means of checkered partitions which also acted as supports for the hearth. Dividing the chamber in this way gave each burner a separate, unobstructed compartment into which to fire. The checkered piers assisted in distributing the heat more uniformly over the entire hearth area. With this new construction the hearth life was increased from an average of six months to eighteen months. However, the hearth life at the carburizing temperature was not greatly increased.

The temperature differential which existed in the annealing chamber after soaking was greatly reduced but the differential which existed between top and bottom of charge during the heating up period was not reduced to any great extent. This differential was usually 100 degrees or more at the time the top of the charge reached 1400 degrees and could be attributed to the poor heat conductivity of the fire brick hearth.

The next step in the improvement of the furnaces was the installation of a silicon carbide hearth. This

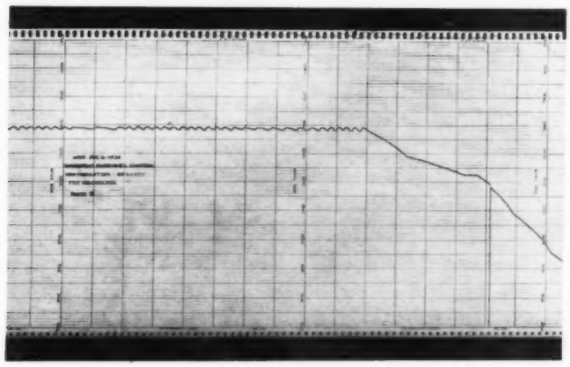

FIG. 3

change further increased the hearth life and also greatly decreased the temperature differential between top and bottom of charge during the heating up period. To date the first silicon carbide hearth installed has withstood 27 carburizing heats as against four for the clay hearth. Based on this performance alone the silicon carbide has more than paid for itself. The ratio of cost of the silicon carbide installation to the clay installation is 3 to 1 while the performance ratio is approximately 7 to 1. The hearth is still in very good condition.

Having improved the operating conditions considerably it was deemed advisable to investigate automatic temperature control. Fig. 2 shows a temperature curve made at the time the investigation was started. The curve represents the temperature in two

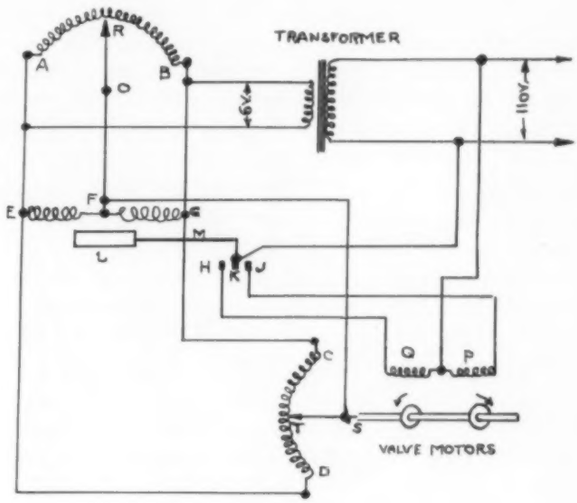

FIG. 4

furnaces of the bank. One couple was placed in each furnace at about the mid point. The curve tells its own story of the need for better control.

A two position type of automatic valve was selected for trial. This type of valve operates either on and off or with a maximum and minimum setting. When the furnace temperature falls off five degrees or more the control instrument closes the valve motor circuit and the valve is fully opened. The amount of oil which now flows through the burners is governed by the valve setting at the burner. As the furnace temperature rises, another contactor in the control instrument is closed; the valve motor is reversed and the valve is fully or partially closed depending on the position of the hand wheel at the bottom of the automatic valve. When the wheel is turned to the right the valve cannot close completely and a minimum amount of oil will flow. Turning the hand wheel as far as it is possible to turn it to the left allows the valve to close completely and we then have on and off operation. The corresponding air adjustments are made by adjusting screws at each end of the air valve

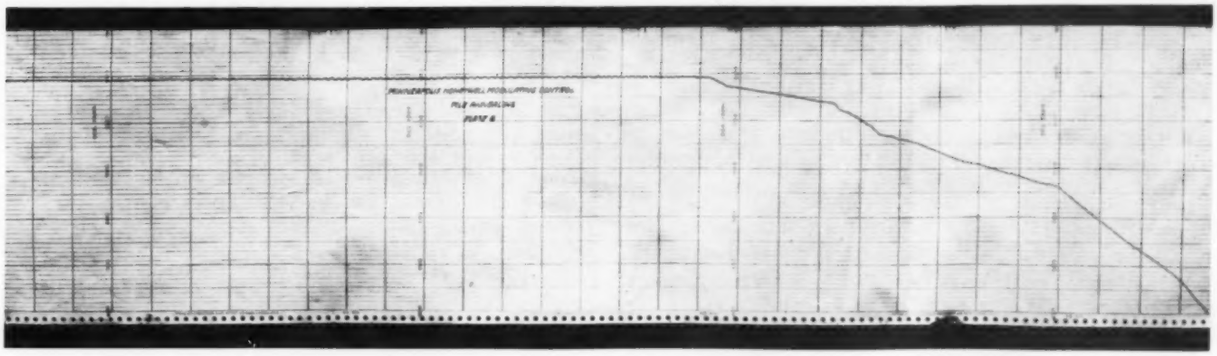

FIG. 5

travel. A temperature curve obtained with this valve is shown in Fig. 3. The maximum variation is approximately 20 degrees. The 20 degree variation can be analyzed as follows: The controller which produced this curve was set for 1380 degrees. At the time of valve opening the furnace temperature was falling. It continued to fall—5 degrees—until the heat input from the burners overbalanced the furnace losses. At this instant—which is the lowest point on the curve—the furnace temperature starts to rise and continues to rise even after burner shut down — 1380 degrees — because the heat input is greater than required. The excess heat, which is stored up in the furnace refractories, carries the furnace temperature to the high point on the curve where a balanced condition again exists until furnace losses overbalance the available heat within the furnace. The furnace temperature falls and valve opening again occurs.

Even with the 20 degree swing the temperature curve of Fig. 3 is a great improvement over that of Fig. 2.

After an extended trial period with the two position control valve it was decided to equip the entire bank of furnaces with automatic control. At this time the proportioning type of valve was selected. This valve has the same physical appearance as the two position valve but it differs from this valve in that it has two motors; one for each direction of rotation. These motors are mounted on a single shaft. Also, there is mounted within the unit a potentiometer slide wire the function of which will be described later on in the paper. The maximum setting for this valve is obtained by adjusting the valves at the burners as with the two position valve. After the furnace has reached the control temperature an indicator valve, which is placed in the line ahead of the automatic valve, is turned down so that the amount of oil flowing through the automatic valve at any time is greatly reduced. A screw adjustment is made on the butterfly air valve so that maximum amount of air flowing is also reduced. Making these adjustments is the equivalent of changing from a parallel to series connection or otherwise reducing the power input of an electric furnace.

An explanation of the automatic operation of the proportioning control valve will be attempted with the aid of the wiring diagram in Fig. 4. The potentiometer coil AB which is mounted in the control instrument is identical with the coil CD which is mounted in the automatic valve. Slider OR moves across the coil with variations of temperature in the furnace. Slider ST is fastened to and revolves with the motor shaft in the valve. EF and FG represent two oppositely wound coils of a solenoid. L represents the solenoid plunger. Connected to L is arm M and contact K. As L moves to right or left K makes with J or H respectively and in turn valve motor P or Q is energized from the supply source. Coil AB is .625" long and consists of approximately 80 turns of #33 wire. It represents 35 degrees of temperature in the furnace. From the foregoing facts it will be seen that each turn of wire on AB represents 35/80 degrees of heat or approximately .44 degrees. In order to simplify the explanation let it be assumed that each turn represents .5 degrees. Then each degree will represent two turns of wire on AB.

Since the circuit is essentially a Wheatstone Bridge circuit a balanced condition exists when OR and ST are in the mid positions on AB and CD. At this time the current through EF will be equal to that through FG and plunger L will be in the mid position of the solenoid. Therefore, K will also be in the mid position between H and J and neither motor Q or P will be in motion.

Let it now be assumed that the furnace temperature falls off one degree. When this happens slider OR will move a distance of two turns and thereby unbalance the circuit. FG now has more current flowing through it than does EF and consequently plunger L moves to the right and closes the circuit for motor P. When motor P revolves the valve starts to open. However, as soon as P revolves slider ST also revolves (being fastened to the motor shaft) and as soon as it has moved a distance two turns on CD, the circuit is again balanced and the current of EF equals that of FG. The plunger L again returns to the mid position thereby opening KJ. The motor then comes to rest and the furnace operates at a valve setting corresponding to a two degree unbalanced temperature condition. As the temperature in the furnace rises one degree slider OR moves two turns to the left and the circuit is again unbalanced but in the opposite way. EF now overpowers FG and the plunger L is moved to the left and the valve is slightly closed. This slight closing and opening of the valve continues until a heat balance between the heat input and furnace losses occurs. When this happens the valve comes to rest and the temperature curve approaches a straight line.

A curve made with this unit is shown in Fig. 5. The maximum variation of the control point is ten degrees and there are several intervals on the curve where a balanced condition was maintained for several minutes. Because of the small increments of valve movement the temperature curve made by proportioning valve has less swing than that made by a two position valve.

The writer believes it has been shown that the operating conditions of oil fired furnaces can be greatly improved with the use of modern materials and proper control equipment.

TENTATIVE PROGRAM

CONVENTION AND IRON AND STEEL EXPOSITION

AUSPICES

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS ELECTRICAL—MECHANICAL—LUBRICATION—COMBUSTION—WELDING AND SAFETY DIVISIONS

CLEVELAND, OHIO — SEPTEMBER 18, 19, 20, 1934

TUESDAY, SEPTEMBER 18, 1934

Mechanical, Electrical and Lubrication Engineering Divisions,
Technical Sessions, Ball Room, Mezzanine Floor, Statler Hotel.

"Developments in the Iron and Steel Industry."
"A Review of Sheet, Tin and Strip Mills."
"Electrical Equipment for High Speed Precision Merchant Mills."
"Precision Rolling Mills."
"Billet Cleaning."

Safety Engineering Division,
Technical Session, Ball Room, Mezzanine Floor, Statler Hotel

"Industrial Relations."

Iron and Steel Exposition visit by National Officers, National Engineering Committees, Membership and Guests—Cleveland Public Auditorium, Cleveland, Ohio.

Reception for Maintenance Engineers of City of Cleveland at Iron and Steel Exposition, Cleveland Public Auditorium.

Exhibitor's Informal Dance—Ball Room, Statler Hotel. Members, Guests and Exhibitors invited.

WEDNESDAY, SEPTEMBER 19, 1934

Lubrication Engineering Division

Technical Session, Ball Room, Mezzanine Floor, Statler Hotel.

"Servicing of Steam Turbine, Diesel and Transformer Oils."
"New Developments in Lubrication."
"Oiling System Installation — Piping and Arrangement."
"General Discussion—Lubrication Problems."

Electrical Engineering Division

Technical Session, Lattice Room, Statler Hotel.

"Electrical Characteristics of Main Drive Motors in Connection with a 76" Hot Strip Mill."
"Special Motor Applications in Connection with Run Out Tables 72" Hot Strip Mill."

Inspection Trip to Otis Steel Company, Cleveland, Ohio. Members, Guests and Exhibitors invited. Trip must be made in special buses leaving the Statler Hotel.

Visit to Iron and Steel Exposition, Cleveland Public Auditorium. Buses will bring Inspection Trip group to Iron and Steel Exposition.

Exhibitor's Reception and Dinner, Exhibit Hall, Cleveland Public Auditorium.

THURSDAY, SEPTEMBER 20, 1934

Combustion Engineering Division,
Technical Session, Lattice Room, Statler Hotel

"Relative Value of Fuels as Applied to the Steel Industry."
"The Design, Construction, Installation and Operation of Blast Furnaces."
"The Generation of Power in Industry by Diesel Engines Using Heavy Fuel Oils."
"Increasing the Output of Steam Power Plants by Superimposing High Pressure Turbines and Boilers."
"Control of Open Hearth Furnaces."
"Gas Fired Ingot Heat Treating Furnaces."
"The Industrial Uses of Propane and other Liquified Petroleum Gases."

Welding Engineering Division,
Technical Session, Ball Room, Mezzanine Floor, Statler Hotel

"High Spots in Welding."
"Nitrogen in Arc Welds."
"Gas Welding and Cutting Relative to the Iron and Steel Industry."
"Aluminum Welding."
"Tube Control in Connection with Resistance Welding."
"The Application of Meters to Welding."
"Thermit Welding—Its Economic Importance in Steel Mill Maintenance."

Formal Reception and Dance, Ball Room, Mezzanine Floor, Statler Hotel.

IRON AND STEEL EXPOSITION

With about 75% of the space contracted for, the Iron and Steel Exposition to be held in conjunction with the 30th Convention, promises to be one of the outstanding features of the convention. As in the past years, the diversity of products to be exhibited is marked. Some of the steel mill equipment to be exhibited will be combustion control equipment, antifriction bearings, lubrication devices, motor and control equipment, the latest in material handling equipment, and practically all makes of maintenance equipment used in the steel industry.

EXPOSITION HOURS

(Opens) Tuesday, 1:30 to 5:30 P. M. Evening, 7:00 to 10:00 P. M.
Wednesday, 10:00 A. M. to 10:00 P. M.
Thursday, 10:00 A. M. to 10:00 P. M. (Closes.)

Collective Bargaining— The Employee Representation Plan

By TOM M. GIRDLER
Chairman of the Board and President,
Republic Steel Corporation.

The current widespread epidemic of strikes or threatened strikes in the United States may have at least one useful result—it may help to clarify the issues involved and to bring before employees, employers, and the public at large the actual nature of the controversy existing between leaders of organized labor and leaders of industry.

The experience of the steel industry is particularly illustrative of these points.

From propaganda put out by labor leaders, many people have, no doubt, gained the impression that the steel industry is opposed to collective bargaining.

This is not true. The industry stands squarely in favor of the right and the practice of collective bargaining with its employees.

The point in controversy has to do with the form of collective bargaining which is to be adopted.

The steel industry believes that the employee representation plan represents the best form of collective bargaining, for employees as well as employers, which has thus far been devised.

TOM M. GIRDLER

Labor unions, however, chiefly those affiliated with the American Federation of Labor, temporarily taking a dominating position under NRA and seeking governmental support out of all proportion to their memberships, are attempting to force the "closed shop" upon employees and employers alike, and claiming the exclusive right to represent employees in collective bargaining.

This is as objectionable to the great majority of the employees as it is to the employers. In the steel industry, only a small minority of the total number of employees belong to trade unions.

The steel industry has refused to recognize the unions because trade unionism means eventually the closed shop—and the closed shop, in the opinion of the industry, is absolutely contrary to the best interests of both employees and employers and in violation of Section 7-A of the National Industrial Recovery Act, which guarantees to all employees free choice of method of bargaining with employers.

Furthermore, in opposing the closed shop and union recognition, the steel industry has in mind past experience with American Federation of Labor unions—and that experience, with its examples of jurisdictional disputes, strikes, excessive dues, fines and penalties, limitation of output, philosophy of conflict, and intrusion of agents having little or no acquaintance with the industry or the rank and file of the employees they claim to represent, has not been conducive to the satisfaction of the employees or of the management.

The majority of employees in the steel industry, as well as the employers, believe that collective bargaining may best be accomplished in the interests of the employees themselves, as well as those of business and society at large, by the establishment of self-governing employees' organizations within the industry, whereby employees are free to elect representatives to deal with employers upon questions of wages, hours, working conditions, and all other matters of mutual interest.

Contrary to general opinion, the employee representation plan of collective bargaining is not new. It has been in use for years in many industries, including steel.

The employee representation plan is often referred to as a "company union." To the extent that this term indicates an organization of employees of a company for collective bargaining, this name is correct. However, the implication that management controls the affairs and decisions of the employee organization is absolutely unwarranted. In order for an employee representation plan to function ef-

fectively, it is absolutely essential that employees have the right of independent meetings, elections and conclusions.

Under the employee representation plan, the employees of a company elect annually a definite number of representatives who will represent them in dealings with the management.

Supervisory employees, foremen, officers, and the like, are not permitted to vote or to act as employee representatives. Elections are entirely in the hands of the employees and conducted by secret ballot. The company takes no part in the elections.

The representatives elected select their own chairman and appoint their own committees and sub-committees. Regular meetings of these committees are scheduled for the discussion of any problems which may be raised by the employees. At agreed intervals, employee representatives meet jointly with representatives of the management in order to facilitate the placing of questions raised by employees before the management, and to maintain a mutual interchange of opinions and ideas.

Any employee who has a suggestion to offer, or believes that he has a grievance, may immediately bring up the matter with the proper employee representatives' committee, who may, in turn, take the issue to the management. Decision is then reached by mutual discussion between management and employee representatives. If, however, an agreement cannot be reached, the question may then be referred for arbitration.

Questions settled and discussed under the employee representation plan include wages, hours and working conditions, safety, health, sanitation, athletics, recreation, education, housing, shop practice, the condition of the company's business, and the like. The most intimate details of the business are discussed under these circumstances with a mutual understanding and confidence which would not and could not be done under any other arrangement.

Participation in an employee representation plan is purely voluntary. An employee may belong to a different type of labor organization, if he so chooses. There is no discrimination against him for that reason. The principle of free choice is one of the foundations of the plan.

However, in most plants where the employee representation plan has been functioning for any substantial period of time, by far the great majority of employees participate in the plan—and for that reason their representatives possess a unified opinion sufficient to lend the necessary weight to their conclusions.

It is of particular importance to review the advantages which the representation plan affords to the employees themselves—as contrasted with the method of collective bargaining offered by union labor. Among them are the following:

(1) Union labor appears to have been built upon the theory that the interests of employers and employees are inevitably antagonistic—that there must be in the nature of things, a perpetual conflict between employer and employees. This accentuates class differences, promotes bitterness and hostility, fosters dissatisfaction and friction, and drives a wedge between men and management. It is productive of no profit to anyone concerned.

The employee representation plan builds harmony, confidence, and understanding between employer and employees, and gives workmen a means of collective bargaining which will work to the mutual benefit of both employees and management.

(2) Under union labor, employees are represented by outsiders, often men of no mill experience, little familiarity with plant conditions, and interested chiefly in collecting dues and building up their own incomes and importance.

Under the employee representation plan, employees are represented by men whom they know personally—men who are thoroughly familiar with local conditions and know what they are talking about from experience.

(3) Leaders of union labor, in order to justify their existence, frequently deliberately create dissatisfaction, strife, disorganization, and strikes—making promises as to wages, hours, and working conditions which are impossible of fulfillment, simply in an effort to try to maintain their following among the men. The result is often destruction of confidence, falling off of business, decline in orders, and the necessity of taking men off pay rolls. Thus organized labor in the long run defeats the best interests of the employees themselves.

Under the employee representation plan, employees as well as employers work together to preserve confidence and harmony which will make for better business and, in the long run, for better wages.

(4) Under union labor, when a question comes up between men and management, the union leaders who are supposed to represent the men may be miles away in a different city, and days may pass before they can take up the question with the management. When they do arrive, the union leaders may not know local conditions, and may not make allowances for variations between different plants or different cities. Labor unions are too large for their men to give day-to-day consideration to issues arising at various plants.

The employee representation plan provides for day-to-day action. Issues which arise may be discussed and settled immediately, and local matters pertaining to each plant may be taken up and settled in a manner satisfactory for that particular plant.

(5) Under union labor, an employee has no right as an individual. He is not allowed to take his case before his employer or make his own bargain with his employer, if he prefers to do so. Furthermore, under the closed shop demanded by the union, a man must belong to the union or lose his job.

Under the employee representation plan, any em-

In the July issue of the Rotarian —whose permission we have received to reprint—there is presented an exchange of opinion upon the question of THE EMPLOYEE REPRESENTATION PLAN versus TRADE UNIONISM. Of interest to the readers of the Iron and Steel Engineer should be the following remarks of Tom M. Girdler, Chairman of the Board and President, Republic Steel Corporation, who defends the employee representation plan against William P. Connery, Jr., Chairman, Committee on Labor, United States House of Representatives, who speaks for trade unionism.

ployee may present his individual case at any time. He may participate in the plan or not, as he chooses. He is guaranteed his right to free choice and free action.

(6) Trade-unionism strives to prevent men from broadening their experience or increasing their usefulness. It allows no man to do any form of work except that which falls under his own trade. It objects to promotion on the basis of reliability or merit.

The employee representation plan gives free play to individualism, encourages the use of the incentive system, permits recognition of superior ability, and offers employees opportunity for advancement based upon capacity for leadership, proven intelligence, and production efficiency.

(7) Payment of dues is the one essential qualification for membership in a labor union. Under a closed shop, if a union man does not pay his dues he is not only forced to leave his job, but is prevented from securing any other job in a union shop.

No dues are required to participate in the employee representation plan. Under this plan, the management recognizes the right of employees to elect representatives, to bargain collectively, and to consider all problems having to do with employee welfare, **as an inherent privilege.**

How the representation plan actually works out in practical operation may best be shown by actual facts and figures.

A survey made by the American Iron and Steel Institute of activities in employee representation plans during the first four months of operation under the Steel Code demonstrates how successfully these plans are meeting problems arising in the day's work.

Reports were received from large and small plants which employ 285,000 workers, nearly 70 per cent of all those then employed in the industry. During the four months covered by the survey of July to October, 1933, some 1,361 meetings were held and 4,082 cases were referred to representatives or to committees for consideration.

There was actual collective bargaining between employees and management in all the cases considered with the result that employees' requests were granted in 70 per cent of such cases; 18.3 per cent of them were decided in favor of the employers; 4.6 per cent were withdrawn and 7.1 per cent were compromised.

The experience of our own company is typical. During the first ten and a half months the plan was in operation, 1,536 different matters were discussed and settled. Of this number 72.5 per cent were settled in favor of employees, 12.5 per cent were settled in the negative, 3.3 per cent were withdrawn by the employees, 3.7 per cent were compromised, and only 8 per cent of the total cases were still pending settlement as of May 1, 1934.

It is especially interesting to note that 1,142 cases, or 74.3 per cent of the total, had to do with employment, working conditions, wages, safety, and welfare, which are, of course, the most important matters in which employees are interested.

The results obtained show that employee representatives know the needs and views of employees, and have not hesitated to step forward and present these needs and views to management—and they have gotten remarkable results.

Anyone who has seen the representation plan in operation, and has watched employee representatives stand up in joint meetings with management representatives and state what the men wanted and why they wanted it, would be amazed at the intelligence and effectiveness with which the employee representatives function, and would realize in an instant how utterly unfounded were any suspicions of company domination.

These men are not afraid. They have no reason to be. They tell their side of the story to management without hesitation, and in no uncertain manner. Management representatives act in the same spirit.

One important result of this complete frankness is that the employees are taken into the confidence of the management and told facts and figures having to do with costs and earnings. In this way the men obtain a reasonable understanding of their employer's production and financial problems, so that they can realize the nature of the factors upon which employers' decisions are based. A situation of this sort would be utterly out of the question under a union labor regime.

This is simply another instance of the manner in which the employee representation plan substitutes for the old spirit of conflict the new spirit of cooperation and conference in industrial relations.

In the steel industry, the great majority of the men—to the best of our information—have already indicated that they prefer the employee representation plan. Neither these employees nor the management will be willing to submit to the dictates of a minority, dominated by outside organizers, who are urging the retention of obsolete and antiquated methods of employee organization which have neither excuse nor usefulness in an era of enlightened industrial relations.

SPECIAL FEATURE

Iron and Steel Exposition, September 18, 19, 20, 1934

Industrial Lighting Exhibit

Auspices

ELECTRICAL LEAGUE of Cleveland

1,200 Square Feet Devoted to

BETTER ILLUMINATION
BETTER SEEING
BETTER LIGHT and BETTER SIGHT
for
INDUSTRIAL AND STEEL PLANTS

Make your own tests of your lighting efficiencies at your plants then compare them with the NEW Improvements to be shown at the

LIGHTING SHOW

*Better Lighting is a Production Tool for Industrial and Steel Plants**

Coke Oven Departments
Open Hearth Plants
Finishing Mills
Machine Shops
Sheet and Tin Mills
Bar Mills
Wire Mills
Skelp Mills
Galvanizing Departments
Rivet and Bolt Departments
Carpenter Shops
Packing Departments
Storage Yards
Inspection Departments
Blast Furnaces
Rolling Mills
Power Houses
Pipe Mills
Strip Mills
Rod Mills
Plate Mills
Coupling Departments
Pickling Departments
Blacksmith Shops
Pattern Shops
Shipping Departments
Office Buildings
Chipping Departments

All Maintenance Shops

To SEE better is to understand MORE.

Attend the Iron and Steel Exposition

SEPTEMBER 18, 19, 20, 1934

CLEVELAND PUBLIC AUDITORIUM, CLEVELAND, OHIO

*The Steel Industry purchases over $2,000,000 worth of Lighting Equipment each year.

ITEMS OF INTEREST

PERSONNEL CHANGES

At a special meeting of the Board of Directors of The Timken Roller Bearing Company held June 16, H. H. Timken resigned as president of the company, and William E. Umstattd was elected president. Mr. Timken remains as chairman of the board.

Mr. Umstattd has been with The Timken Roller Bearing Company since leaving the Army in 1919 and has worked in all departments of the plant, being advanced to assistant superintendent, assistant factory manager, and until January, 1932, was factory manager. Mr. Umstattd was then advanced to the position of executive vice president, so that for the last two and one-half years he has had intimate contact with all activities of the company, including financial, selling, production and general company policies.

Henry H. Timken, Jr., was elected a vice president of The Timken Roller Bearing Company and a vice president of The Timken Steel & Tube Company.

▲

K. B. Bowman has been appointed general superintendent of the steel mill of Timken Steel & Tube Co., Canton, O. Graduated from Case School of Applied Science, Cleveland, in 1921, he immediately became associated with the steel industry. He has been with the Central Steel Co., Central Alloy Steel Co., and Republic Steel Corporation, his experience covering metallurgical and operating practice. He joined the Timken company in 1931 as special statistician for the president, F. J. Griffiths. In 1933 he was made director of production, in which capacity he has acted until his recent appointment.

▲

Robert E. Brooke, formerly president of the Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., has been elected chairman of the board. John E. McCauley, heretofore vice president and general manager, has been made president. George Brooke has been elected a vice president.

▲

John C. Hopkins, formerly associated with the Central furnace division of the American Steel & Wire Co., Cleveland, since 1922, as superintendent of Central furnaces and since 1929 general superintendent of blast furnaces and steel plants, has been appointed district sales manager of the Cleveland office of the General Refractories Co., Philadelphia.

▲

Fred T. H. Youngman, who for the past 15 years has been secretary-treasurer of the Jessop Steel Co., Washington, Pa., has been appointed vice president. He will continue as treasurer. R. J. Murray, II, assistant secretary for the last six years, has been made secretary.

▲

Cassius M. Davis, assistant engineer of the General Electric Company's transportation department at Erie, Pa., has been appointed engineer of the department, succeeding H. L. Andrews who was recently elected a vice president of the company.

W. C. Harris, another assistant engineer of the same department, will continue in that position, acting in addition in general charge of the department in the absence of Mr. Davis. Mr. Harris' particular duties will be questions of design engineering and co-ordination of design engineering and manufacturing.

▲

In order to better serve the southeastern states The Louis Allis Co. has recently opened a direct factory branch office in the Bona Allen Building in Atlanta.

The territory served from this office includes the States of North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee and Mississippi.

Local sales offices located in Birmingham, Charlotte, Greenville, and nineteen service stations located at strategic points through the above states will be under the supervision of the newly established Atlanta district office.

The Atlanta office and southeastern territory is in charge of George C. Gardner, who has been identified with the electric motor industry in Atlanta and the south for many years.

▲

Dr. J. F. Thompson, vice president, The International Nickel Company, Inc., has announced the appointment of D. A. Nemser as development engineer, with headquarters in Hartford, Conn.

▲

The Harnischfeger Corporation of Milwaukee, manufacturers of industrial and contractors' equipment, have just announced the appointment of Frederick Salditt as manager of the export division.

Mr. Salditt brings to his new position a wealth of experience accumulated through many years with the corporation in shop offices, service, engineering, sales and foreign departments.

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WITH THE MANUFACTURERS

For motors up to 15 HP, 220 volt, and 30 HP, 440-550 volts, The Electric Controller & Mfg. Company, E. 79th street and Woodland avenue, Cleveland, O., announce the EC&M Type ZO, Weatherproof and Dust-tight, Across-the-line, Oil-immersed Motor Starter.

These starters are enclosed in a case which has been bonderized and then black enameled. When desired, a self-contained ammeter in a dust-tight case can also be furnished. The starter is arranged for remote control, push button automatic operation.

▲

The Timken Roller Bearing Company has received an order from the Edward G. Budd Manufacturing Company for bearings and boxes to be used on a light weight high speed multi-section train for the Brooklyn Manhattan Transit System in New York City and Brooklyn.

▲

A new 80-page reference book on "How to Select

Insulated Cable" has been published by the General Electric Company. Designated as GEA-1837, the publication covers cable for the transmission and distribution of electric power at normal frequencies, and presents in convenient form the information that is required in determining the cable best adapted for a particular installation.

▲

To guard against explosive mixtures of fuel and air when lighting off pulverized coal, gas or oil fired boilers, Bailey Meter Company, Cleveland, O., has developed a control trip which withholds fuel feed until the boiler is thoroughly purged.

The mechanism consists essentially of two oil sealed bells suspended from a beam to measure Air Flow through the boiler. A draft connection from the right-hand bell to the boiler furnace, and a similar connection from the left-hand bell to the last pass provides for the use of draft loss through the boiler as a measurement of Air Flow. The entire mechanism, including oil-sealed bells, snap-acting contactor and indicating pointer, is enclosed in a dust and moisture-proof pressed steel casing of attractive design.

Although this control device is provided with an indicating pointer for calibration and checking, its primary function is to operate the snap-acting contactor in the circular casing between the two oil-sealed bells. This contactor is connected to the Air Flow mechanism by linkage in such a manner that it is necessary to run the rate of Air Flow through the boiler up to approximately 60% of capacity before the contactor snaps closed and permits operation of the fuel feeder motor relay or control valve. Once this contactor goes to the closed position it remains there until the Air Flow value approaches zero, thereby permitting operation of the unit throughout its entire control range without tripping out the fuel feed.

This simple control trip eliminates one of the most serious hazards encountered in the operation of units fired with fuels in suspension. In spite of strict schedules and rigid operating rules, experience shows that the human element is likely to disregard rules and schedules in times of emergency, often with disastrous results.

▲

For applications where the extreme accuracy of Ignitron timing is not essential, the electronic Contactor timers for spot welding described in a two-page leaflet recently issued by the Westinghouse Electric and Manufacturing Company have wide application where a low maintenance timing device is desired. This illustrated leaflet describes the application, distinctive features, operation and construction of the electronic contactor timers.

Copies of the publication may be obtained from the nearest district office or direct from the advertising department.

▲

A new bulletin on furnace pressure control for metallurgical and other industrial furnaces has been issued by the Leeds & Northrup Company, 4901 Stenton avenue, Philadelphia, Pa. Copy of the new Bulletin No. 842 which is entitled "L&N Automatic Furnace Pressure Control" may be secured by writing the above company.

The Lukens Steel Company of Coatesville, Pa., is distributing a new bulletin on Lukens Cromansil Steel, a recently developed high strength steel which is now being furnished in sheet and plate form. Copy of this attractive bulletin may be secured on request.

▲

The Delta-Star Electric Company, Chicago, Ill., have been granted a patent license by the General Electric Company to manufacture Oil-Blast Circuit Breakers.

▲

Two and one-half million precision parts a day held to one ten thousandth of an inch is daily routine at Bantam Ball Bearing Company where the Quill Rollers for the automotive industry are produced.

▲

BLAST FURNACE ASSOCIATION NOTES

C. P. Clingerman, superintendent, Carrie furnaces, Carnegie Steel Co., Rankin, Pa., was elected president of the Eastern States Blast Furnace and Coke Oven Association at the annual meeting of the organization at the Pitt Field Club, Pittsburgh, June 8. Mr. Clingerman, vice president of the Association during the past year, succeeds B. M. Stubblefield, superintendent, Campbell works, Youngstown Sheet & Tube Co., Youngstown, O.

John C. Murray, assistant general superintendent in charge of the Northside division, Jones & Laughlin Steel Corporation, Pittsburgh, was advanced from secretary-treasurer to vice president.

The new secretary-treasurer is S. T. Moran, superintendent of coke ovens, Republic Steel corporation, Warren, O.

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George E. Rose, general superintendent, Wisconsin Steel Works, Chicago, was elected president of the Blast Furnace and Coke Association of the Chicago district at a meeting held at the Gary Country Club, June 6. Other officers elected include: Vice president, L. F. Burress, coke plant superintendent, Illinois Steel Co., Gary, Ind., and secretary, H. W. Johnson, blast furnace superintendent, Inland Steel Company.

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Arthur G. McKee, president of the Arthur G. McKee Co., will deliver a paper before the Thirtieth A. I. & S. E. E. Convention on Thursday, September 20, 1934, Statler Hotel, Cleveland, O. The paper will cover, Design, Construction and Operation of Blast Furnaces. This paper will attract and arouse National interest in all Blast Furnace circles.

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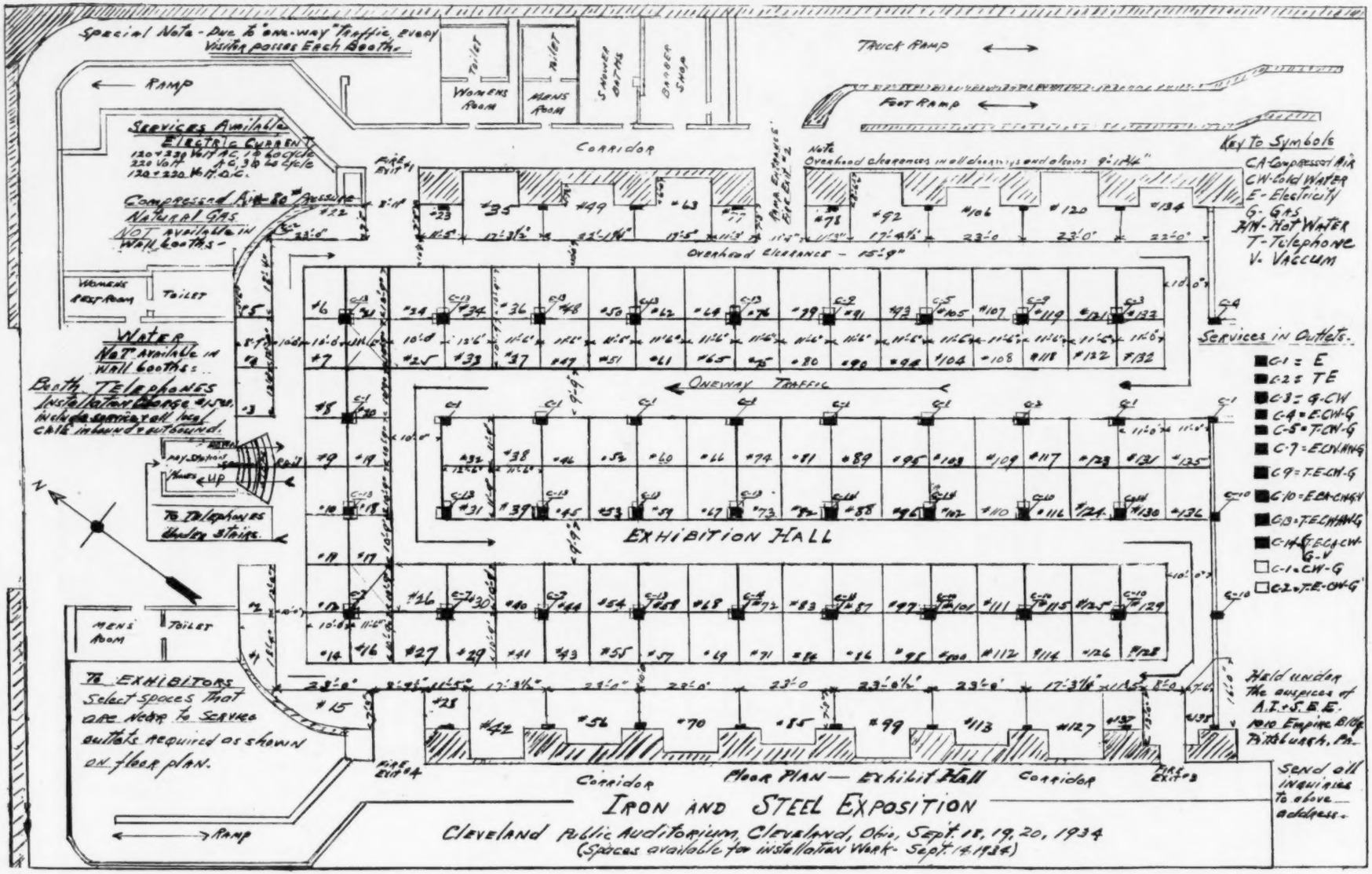
OBITUARIES

Frank G. Cutler, chief, Bureau of Steam Engineering, Tennessee Coal, Iron and Railroad Co., Birmingham, Ala., died in a New York hospital, June 17. He had been associated with the engineering department of the Tennessee company for 28 years. Mr. Cutler had been a very active member of the Association of Iron and Steel Electrical Engineers for 13 years. He took an active part in the forming of the Combustion Engineering Division of the Association and had served on the Executive Committee of the Combustion Division for many years. His opinions as reflected in his discussions on many Combustion subjects were valuable additions to the Proceedings of the Association. Mr. Cutler was one of the best

(Continued on page 278)

IRON AND STEEL EXPOSITION

CLEVELAND, OHIO, SEPTEMBER 18, 19, 20, 1934



Floor plan of the Iron and Steel Exposition to be held under the auspices of the Electrical, Mechanical, Lubrication, Welding, Combustion and Safety Engineering Divisions of the Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, September 18, 19, 20, 1934. An exposition of the developments in apparatus and equipment to process and produce Iron and Steel.

TRUSTWORTHY

The BUSS SUPER-LAG Fuse

STOP
Avoidable Shutdowns

BUSS Super-Lag Fuses have a case designed to prevent the development of poor contact within the fuse. This keeps them from burning up and prevents premature blows and needless shutdowns.

They also have Super-Lag links, which prevent them from blowing on every harmless overload or surge.

If you are interested in preventing *avoidable shutdowns* and in saving time and money, why not drop us a line.

BUSSMANN MFG. CO., St. Louis, Mo.
A Division of the McGraw Electric Co.

(Continued from page 275)

known authorities on Steam and its application, in the Iron and Steel Industry and the membership of the Association extend their sincerest sympathies to the associates, friends and family of this widely known and successful engineer.

▲

Sidney R. Rectanus, vice president in charge of operations of the American Rolling Mill Co., Middletown, O., died in that city, June 22. Recently he had asked to be relieved of his duties with the company in whose employ he had been since 1909, to establish himself as a consultant on management problems. He was elected vice president in charge of operations January 1, 1930.

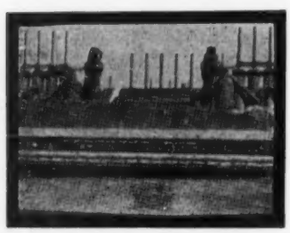
William H. Watkins, former vice president of the Empire Steel Co. and until four years ago superintendent of the Bourne-Fuller Co., in Cleveland, died June 18. He started work in steel mills at the age of 11.

▲

Robert D. Campbell, organizer of the Allegheny Steel Co., Brackenridge, Pa., and senior vice president and a director, died in Orilla, Ont., June 20, while on vacation.

▲

Talmadge Blass, former consulting engineer for the Bethlehem Steel Co. and former superintendent of coke ovens of the Lackawanna Steel Co., in Lackawanna, N. Y., died June 21. He retired in 1922 after long service in the industry.



The Steel Industry At A Glance

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Strip mills are setting the pace in the Iron and Steel Industry. Major electric drives total 77,050 Horsepower since the first of the year, divided as follows: Hot Strip 57,900 HP., Cold Strip 5,000 HP., Sheet Mills 1,650 HP., Rod Mills 4,000 HP., Blooming Mills 7,000 HP.; 36 gear units, 13 AC Motors, 24 DC Motors will main drive the mills represented by the above Horsepower. . . . Watch the cold mill business spurt in 1935 and 1936. . . . Merchant mills of the continuous type for high speed precision rolling will receive a lot of engineering and operating attention during 1934. . . . Anti-Friction Bearings for Roll Necks are coming along strong. . . . The Steel Industry is working hard with new ideas and new methods for billet cleaning. One large company is successfully cleaning billets with steel grit. . . . Strip is being cold rolled on a 4-high experimental mill, the large backing rolls the same diameter while the work rolls have one large and one small roll. . . . A new use for light wall steel pipe is being developed for the electrical field. It will be used for mechanical protection of cable and if successful will supercede the use of ceramic or composition conduit in underground transmission work. This development bears close study by the pipe makers in the Steel Industry. . . . Manufacturers of annealing furnaces are experimenting on continuous furnaces for annealing tin plate. One of the problems to solve is the short pack. . . . A sheet manufacturer is annealing and normalizing stainless steel sheets. . . . Another sheet manufacturer uses their pack and pair heating furnace for normalizing sheets. They use the furnace for pair and pack heating up until Friday evening, then use the furnace for normalizing until Sunday. . . . It is claimed that the electrical energy required for annealing silicon steel (by certain methods) is approximately 240 KWH per net ton, varying of course with the annealing temperature and time cycles employed, a cycle of 100 hours is required. . . . In electric annealing 48" wide sheets requires a total of 96 hours if flatness is desired. . . . The energy required for annealing coiled steel strip in electric bell type furnaces will vary with the requirements. Records show that for low carbon steel average annealing temperature 1320 degrees F. requires 131 KWH per net ton. . . . An annealing furnace manufacturer claims with the use of their particular type of furnace with the elimination of covers and trays a saving is effected of from 45 to 60 cents per ton for steel sheets for galvanizing. Also a reduction of heating time of 30 to 50%. A paper covering this furnace will appear in the August issue of the Iron and Steel Engineer. . . . Material handling equipment, battery driven, is loading sheets and strip from the scales to the floor of the box car for less than 2 cents per ton. . . . Battery trucks are handling coiled strip to the extent of 8000 lbs. to 9500 lbs. . . . The little storage battery is meeting all expectations and more. . . . Number of sheet, tin and strip mill stands quipped with anti-friction bearings total 170 in United States. . . Sixty-nine hot strip mills stands are equipped with anti-friction bearings. . . . A complete resume and tabulation of anti-friction bearings on all types and classes of mills in the United States will appear in the September issue of the Iron and Steel Engineer.

The Youngstown Sheet and Tube Company has placed orders with the crane manufacturers for a 2-60-ton Mill Cranes, 2-25-ton Slab Yard Cranes, 1-15-ton Mill Crane, and 1-60-ton Motor Room Crane. These cranes with an estimated value of $120,000 are to be installed at the new Hot Strip Mill at the Youngstown Plant.